TMDLs for Total Dissolved Solids in the Duchesne River Watershed

EPA Approval Date:

Prepared for:
U.S. Environmental Protection Agency, Region 8
Utah Department of Environmental Quality
Division of Water Quality
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Utah Department of Environmental Quality
Division of Water Quality
TMDL Section

Waterbody IDs	UT14060003-001 Duchesne River from the confluence with the Green River to Randlett.
Location	Duchesne County, Utah
Pollutants of Concern	Total Dissolved Solids
Impaired Beneficial Uses	Class 4 Protected for agricultural uses including irrigation of crops and stock watering
Current Load: **Loading Capacity (TMDL):** **TMDL Load Reduction:**	210,568 kg/day (average observed load over the 0 to 30% flow percentile range) 184,961 kg/day (average allowable load over the 0 to 30% flow percentile range) 25,607 kg/day (average load reduction over the 0 to 30% flow percentile range)
Wasteload Allocation: **Load Allocation** **Margin of Safety**	0 kg/day (no point sources in watershed) 184,961 kg/day (average daily load over the 0 to 30% flow percentile range) 25,607 kg/day (average daily load over the 0 to 30% flow percentile range)
Defined Targets/Endpoints	1) Total maximum daily load as a daily average of less than 184,961 kg/day over the 0 to 30% flow percentile range 2) Load reduction of 25,607 kg/day over the 0 to 30% flow percentile range 3) Water quality target of 1,200 mg/L
Implementation Strategy	1) Irrigation water and riparian best management practices
This document is identified as a TMDL for the Duchesne River Watershed and is submitted under §303d of the Clean Water Act to U.S. EPA for review and approval.	

Utah Department of Environmental Quality
Division of Water Quality
TMDL Section

Waterbody IDs	UT14060003-002 Duchesne River from Randlett to Myton.
Location	Duchesne County, Utah
Pollutants of Concern	Total Dissolved Solids
Impaired Beneficial Uses	Class 4 Protected for agricultural uses including irrigation of crops and stock watering
Current Load: **Loading Capacity (TMDL):** **TMDL Load Reduction:**	225,062 kg/day (average observed load over the 0 to 30% flow percentile range) 184,961 kg/day (average allowable load over the 0 to 30% flow percentile range) 40,101 kg/day (average load reduction over the 0 to 30% flow percentile range)
Wasteload Allocation **Load Allocation** **Margin of Safety**	0 kg/day (no point sources in watershed) 184,961 kg/day (average daily load over the 0 to 30% flow percentile range) 40,101 kg/day (average daily load over the 0 to 30% flow percentile range)
Defined Targets/Endpoints	1) Total maximum daily load as a daily average of less than 184,961 kg/day over the 0 to 30% flow percentile range 2) Load reduction of 40,101 kg/day over the 0 to 30% flow percentile range 3) Water quality target of 1,200 mg/L
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Utah Department of Environmental Quality
Division of Water Quality
TMDL Section

Waterbody IDs	UT14060003-008 Lake Fork River
Location	Duchesne County, Utah
Pollutants of Concern	Total Dissolved Solids
Impaired Beneficial Uses	Class 4 Protected for agricultural uses including irrigation of crops and stock watering.
Current Load: **Loading Capacity (TMDL):** **TMDL Load Reduction:**	265,612 kg/day (average observed load over the 90 to 100% flow percentile range) 254,542 kg/day (average allowable load over the 90 to 100% flow percentile range) 11,070 kg/day (average load reduction over the 90 to 100% flow percentile range)
Wasteload Allocation **Load Allocation** **Margin of Safety**	0 kg/day (no point sources in watershed) 254,542 kg/day (average daily load over the 90 to 100% flow percentile range) 11,070 kg/day (average daily load over the 90 to 100% flow percentile range)
Defined Targets/Endpoints	1) Total maximum daily load as a daily average of less than 254,542 kg/day over the 90 to 100% flow percentile range 2) Load reduction of 11,070 kg/day over the 90 to 100% flow percentile range 3) Water quality target of 1,200 mg/L
Implementation Strategy	1) Irrigation water and riparian best management practices
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ACRONYMS

ACEC	Areas of Critical Environmental Concern
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BMP	best management practice
BOR	Bureau of Reclamation
CRBSCF	Colorado River Basin Salinity Control Forum
CRBSCP	Colorado River Basin Salinity Control Program
CUP	Central Utah Project
DEM	Digital Elevation Model
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
GAP	Gap Analysis Project
GPS	global positioning system
LA	load allocation
LDWP	Lower Duchesne River Wetlands Enhancement Project
MOS	margin of safety
NLCD	National Land Cover Dataset
NRCS	Natural Resources Conservation Service
NWIS	National Water Information System
RMP	Resource Management Plan
SACS	Strawberry Aqueduct and Collection System
SAR	sodium adsorption ratio
STATGO	State Soil Geographic database
TDS	total dissolved solids
TMDL	total maximum daily load
UDEQ	Utah Department of Environmental Quality
URMCC	Utah Reclamation Mitigation and Conservation Commission
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VFO	Vernal Field Office
WLA	wasteload allocation

1. INTRODUCTION

Section 303(d) of the Clean Water Act requires states to develop Total Maximum Daily Loads (TMDLs) for waters that do not meet water quality standards even after technology-based controls are in place. The TMDL process establishes allowable loadings of pollutants or other quantifiable parameters for a waterbody on the basis of the relationship between pollutant sources and instream water quality conditions.

The Utah Department of Environmental Quality (UDEQ) listed several segments in the Duchesne River watershed on Utah's 2004 Section 303(d) list of impaired waters for TDS, as shown in Table 1-1 and Figure 1-1 (UDEQ, 2004a). The beneficial use that is impaired is agriculture. This report documents the development of TMDLs for total dissolved solids (TDS) for the Duchesne River (two segments) and Lake Fork River and development of site-specific criteria for TDS in Antelope Creek and Indian Canyon Creek within the Duchesne River watershed.

These waterbodies are located in northeastern Utah (Figure 1-2) in Duchesne and Uintah Counties and the Uintah and Ouray Indian Reservation. These TMDLs were developed for the U.S. Environmental Protection Agency (EPA) Region 8 and the state of Utah, in cooperation with the Ute Indian Tribe. It is important to recognize that data collection in support of these TMDLs is an ongoing effort and that as new data are collected the TMDLs may be revised accordingly.

Table 1-1. Information for the 2002 303(d) listed segments in the Duchesne River watershed

ID/Name	Assessment Unit Description	Use Class	Use Support[1]	Stream Miles	Pollutant
UT14060003-005 Antelope Creek	Antelope Creek—tribs: confluence Duchesne River to headwaters	4	Non	31.54	Salinity/ TDS/chlorides
UT14060003-001 Duchesne River-1	Duchesne River—tribs: confluence Green River to Randlett	4	Partial	19.52	Salinity/ TDS/chlorides
UT14060003-008 Lake Fork-1	Lake Fork River-tribs: confluence Duchesne River to Pigeon Water Creek confluence	4	Partial	19.65	Salinity/ TDS/chlorides
UT14060003-002 Duchesne River-2	Duchesne River: Randlett to Myton	4	Partial	31.59	Salinity/ TDS/chlorides
UT14060004-002 Indian Canyon Creek	Indian Canyon Creek—tribs: confluence Strawberry River to headwaters	4	Non	43.96	TDS

[1]Full = Criterion was exceeded in fewer than 2 samples and in <10% of the samples if there were 2 or more exceedances
Partial = Criterion was exceeded 2 times, and criterion was exceeded in more than 10% but not more than 25% of the samples
Non = Criterion was exceeded 2 times, and criterion was exceeded in more than 25% of the samples

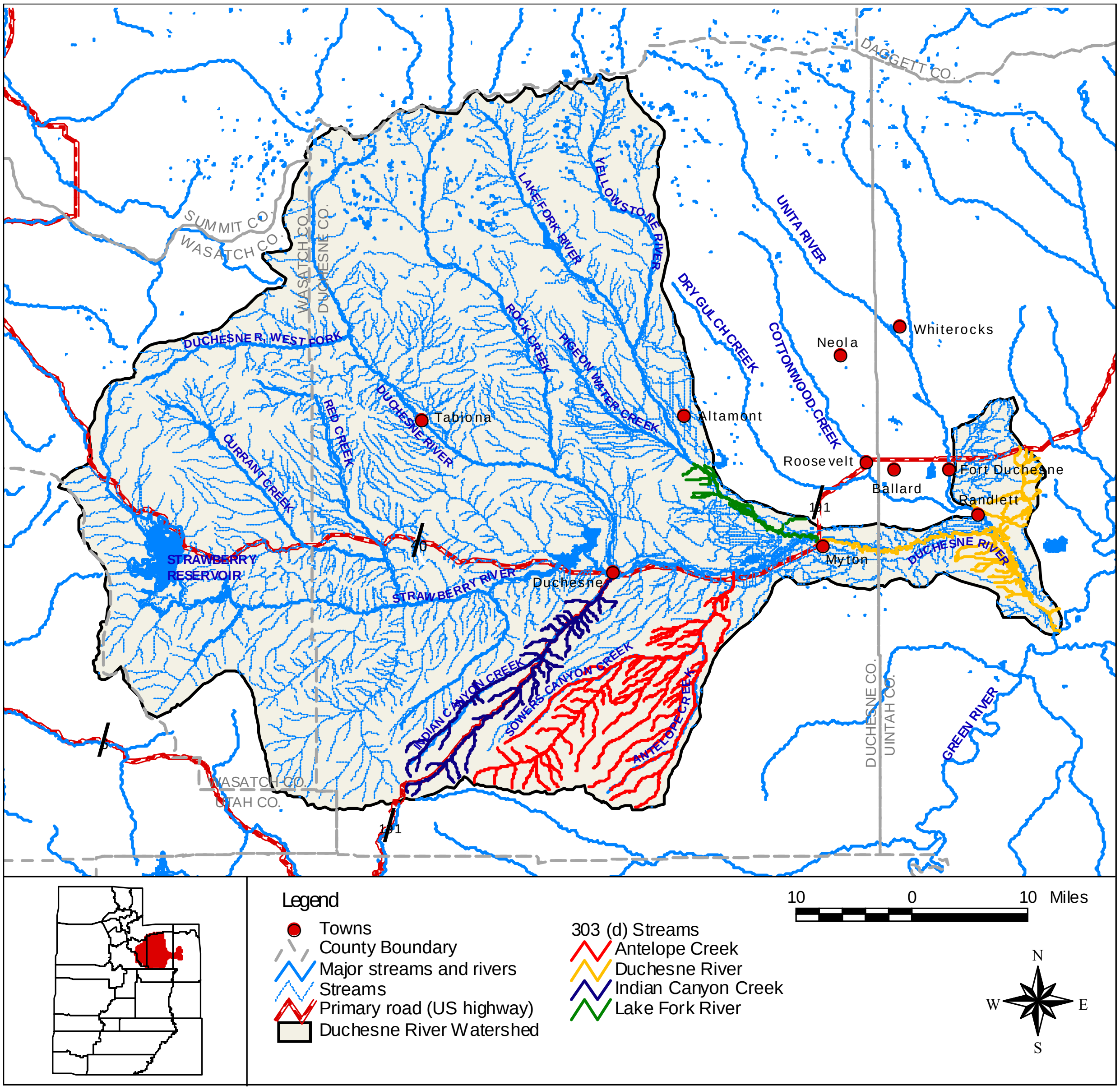

Figure 1-1. 303(d)-listed waters in the Duchesne River watershed

The Duchesne River watershed, part of the Uintah Basin, is located in the northeast corner of Utah (Figure 1-2). The Uintah Basin, an area of approximately 6,969,500 acres (10,890 square miles), includes all of Duchesne, Uintah, and Daggett Counties, and parts of Summit, Wasatch, Carbon, Emery, and Grand Counties. Most of the counties lie between 5,000 to 6,000 feet above sea level, with peaks exceeding 13,000 feet. The Duchesne River watershed is drained by the Duchesne River and its major tributaries—the Strawberry River, Yellowstone River, and Uinta River. In 2002, a TDS TMDL was completed for the Uinta River and Dry Gulch Creek. These drainages are not included in the Duchesne River watershed TMDLs. Indian Canyon Creek and Antelope Creek provide additional drainage for the Duchesne River watershed. The Duchesne River drains into the Green River and, ultimately, into the Colorado River.

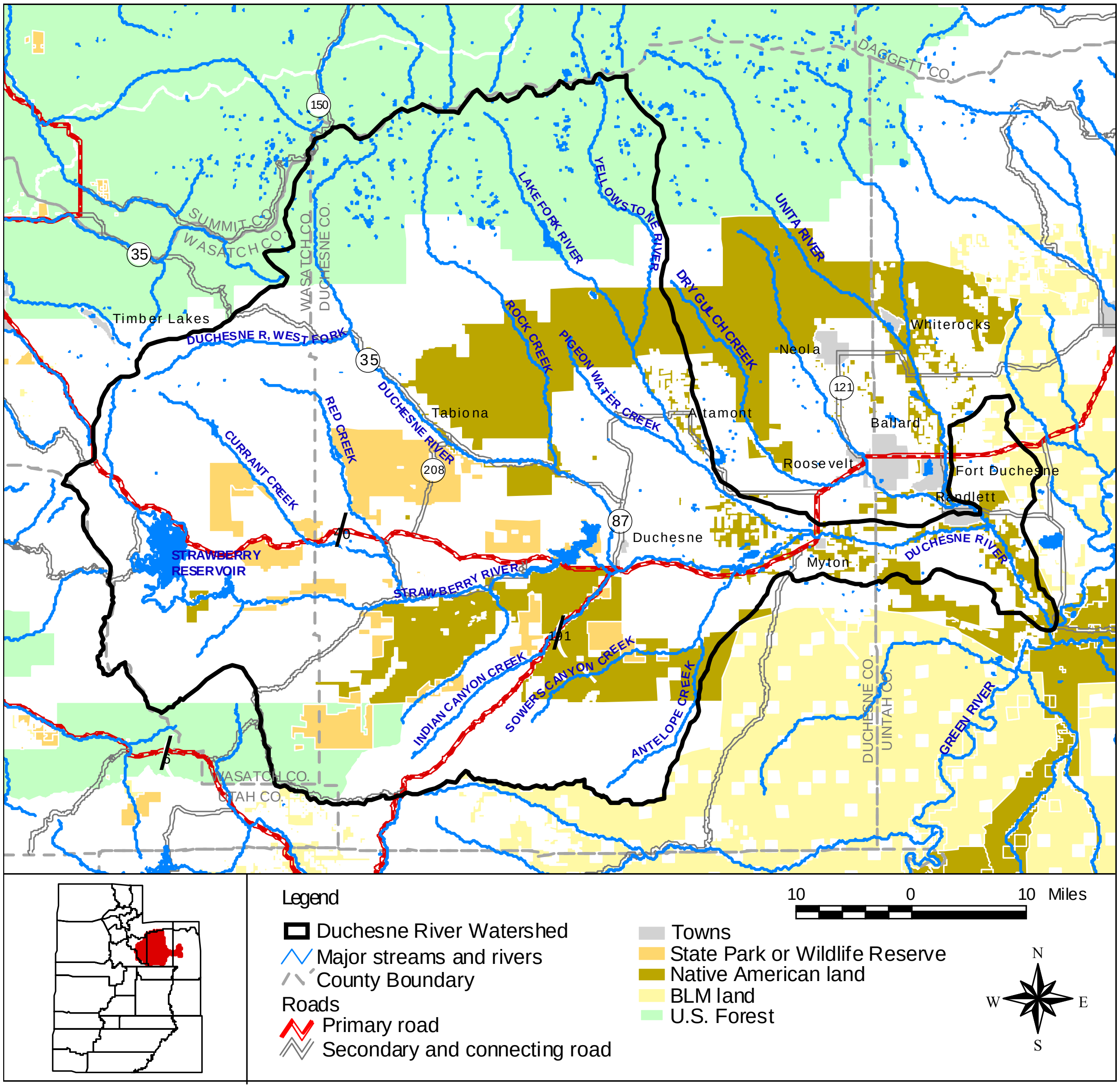

Figure 1-2. Duchesne River watershed

The subsurface bedrock formations in the basin are saline and soluble, dissolving easily and contributing TDS to water flowing through them. The Mancos Shale formation is extremely high in soluble salts. Natural background sources of TDS in the watershed include saline soils and areas of poor drainage where groundwater rises to the surface and evaporates leaving the soluble salts on the surface. This salt efflorescence is then available for washoff and delivery to watershed streams. Precipitation that falls in excess of plant uptake potential and soil holding capacity also percolates down into the shallow alluvial aquifer where it comes in contact with saline bedrock formations. The primary source of human induced TDS loading in the watershed has been attributed to seepage from canals and deep percolation of irrigation water, which then discharges to surface streams as baseflow.

Anthropogenic and natural TDS issues impacting water quality in the Uintah Basin (including the Duchesne River and its tributaries) include an increase in salt loading from inefficient irrigation techniques, erosion of saline soils, and elevated levels of dissolved solids in the shallow alluvial aquifer.

However, the U.S. Geological Survey (USGS) reported in their national summary (1990-91) that there has been a historic downward trend in TDS concentrations in the Duchesne River watershed.

The primary source of groundwater recharge comes from precipitation on the Uinta Mountains that form the northern boundary of the Uintah Basin. Other sources of recharge are precipitation falling on the valley floors, losing stream reaches that flow over unconsolidated glacial till, and deep percolation from unlined irrigation canals. Groundwater discharge occurs primarily along the lower gaining reaches of the Duchesne River from wells and springs. In addition, abandoned seismic wells may contribute to elevated salinity levels in the Indian Canyon Creek watershed.

Sources of TDS in groundwater originate from natural geologic sources, such as the Green River and Wasatch formations. Most of the salt is derived from soils and subsurface parent material of marine origin, which underlie most of the Uintah Basin. Seepage and deep percolation from unlined irrigation canals also dissolve salts from the soils and shales and convey the salts through the groundwater system to natural drainages and, ultimately, to the Colorado River.

There have been a number of studies and activities conducted in the Uintah Basin to address TDS impairments (including the Duchesne River watershed and the surrounding area) and to evaluate irrigation practices, salinity control projects (Figure 1-3), and surface and ground water quality. Because there have been so many activities addressing TDS impairments in this watershed, a more detailed description of these activities and studies are described in Appendix A. Appendix A summarizes the major reports that were reviewed for the development of these TMDLs as well as the major management activities occurring in the area.

It is important to recognize that because load reductions in this TMDL document will focus on natural background and nonpoint sources, implementation of best management practices (BMPs) is purely voluntary. BMPs will preserve current water rights and needs while optimizing use and minimizing deep percolation of irrigation water. If irrigation water is applied in excess of plant requirements, that excess proportion will percolate below the rooting zone where it picks up TDS and returns it to the watershed streams either as surface runoff or groundwater baseflow with elevated TDS concentrations. Because TDS is also washed off watershed surfaces and delivered to receiving streams, potential control options should address surface delivery as well as subsurface delivery of TDS. The key to effectively reducing the anthropogenic TDS loads in the Duchesne River watershed while maintaining current water rights and use is to improve the efficiency of water use and transport and to minimize surface runoff, seepage, and deep percolation.

TMDLs for the Duchesne River watershed were calculated using a statistical method relating TDS loads to the frequency of observed flows in the stream segments. The load duration approach uses flow with observed TDS data to estimate existing loads and with the TDS TMDL target to estimate allowable loads over a range of flow percentiles. Section 6 of this report describes the approach, and Section 7 presents the results of the TMDL analyses for each impaired segment in the Duchesne River watershed.

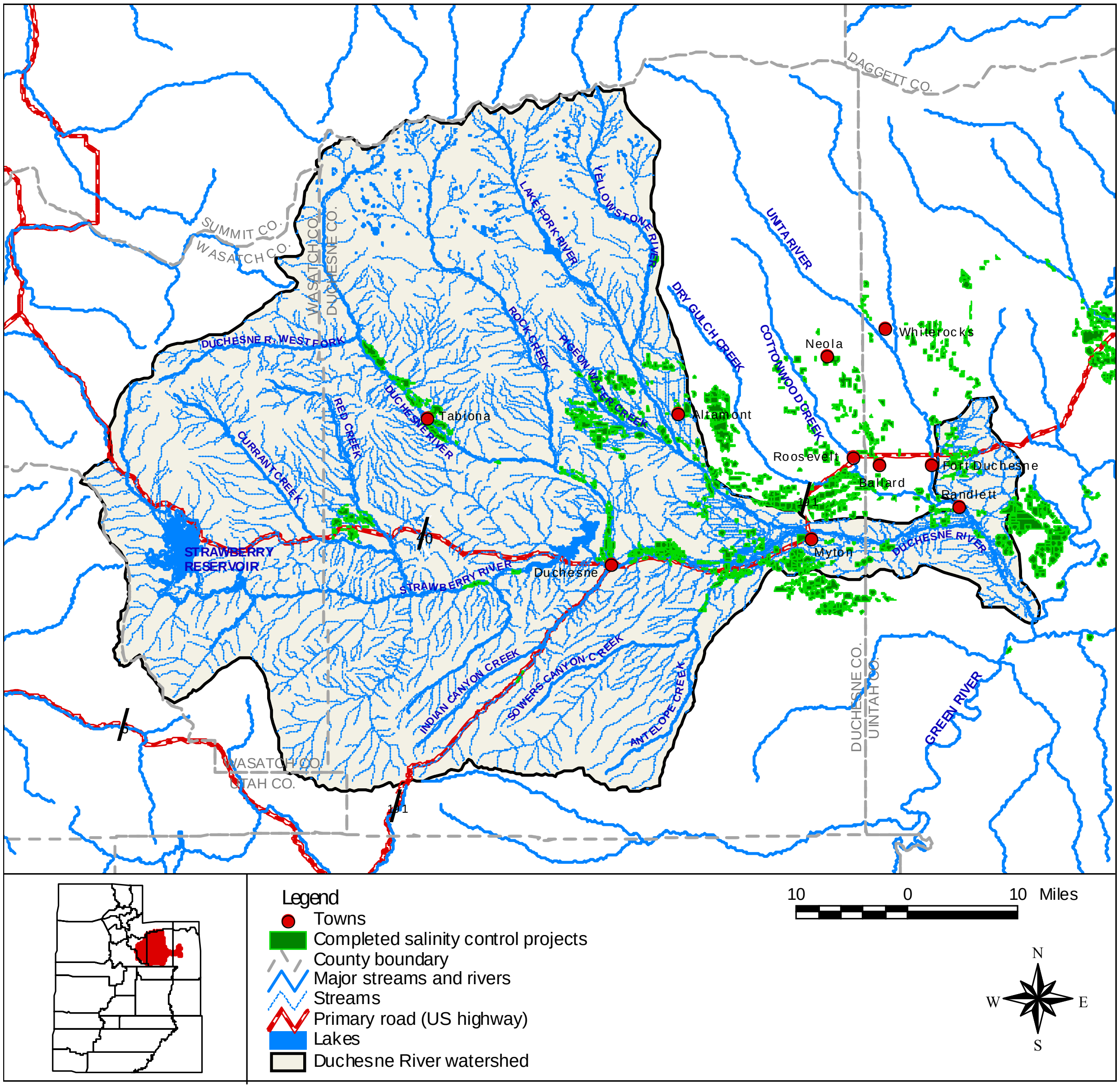

Figure 1-3. Locations of salinity control projects in the Duchesne River watershed

2. WATERSHED CHARACTERISTICS

This section summarizes the major watershed characteristics of the Duchesne River watershed, including location, topography, land use and cover, soils, land ownership, climate and hydrology.

2.1 Location

The Duchesne River watershed (excluding the Uinta River drainage) drains approximately 735,304 hectares (1,816,977 acres) in northeastern Utah (Figure 1-1). The Duchesne River drainage is bounded by the Uinta Mountains to the north, the Green River to the east, the Wasatch Mountains to the west, and the Tavaputs Plateau to the south. It occupies approximately 40,660 hectares (100,474 acres) of Summit, Uintah, and Utah Counties, with the remainder of the watershed in Duchesne (527,029 hectares) and Wasatch (168,168 hectares) Counties. Duchesne County has a population of 14,371 while Uintah County has a population of 24,644. Uintah County is one of the least densely populated counties in Utah and approximately 10 percent of county residents are Native American (BLM, 2005).

The Uintah and Ouray Reservation is approximately 150 miles east of Salt Lake City and 40 miles west of the Colorado border. The reservation lands cover a large portion of western Uintah and eastern Duchesne Counties. The Ute Tribe has ownership of almost one quarter of the total land area of the Uintah Basin and approximately 17 percent of the Duchesne River watershed. Tribal enrollment is approximately 3,174 and is expected to reach 4,600 members by 2010. Approximately 85 percent of tribal members live within the boundaries of the reservation (USEPA, 2005; BLM, 2005).

The Duchesne River watershed is composed of two 8-digit USGS hydrologic cataloging units—Strawberry River (14060004) and Duchesne River (14060003). The Strawberry River drains east until its confluence with the Duchesne River where the Duchesne River watershed begins and continues east to its confluence with the Green River.

2.2 Topography

Topography is an important factor in watershed management because stream types, precipitation, and soil types can vary dramatically by elevation. Figure 2-1 displays the general topography in the Duchesne River watershed. Elevation ranges from 4,109 meters (13,481 feet) above sea level in the headwaters of Yellowstone River to 1,417 meters (4,649 feet) at the Duchesne River-Green River confluence.

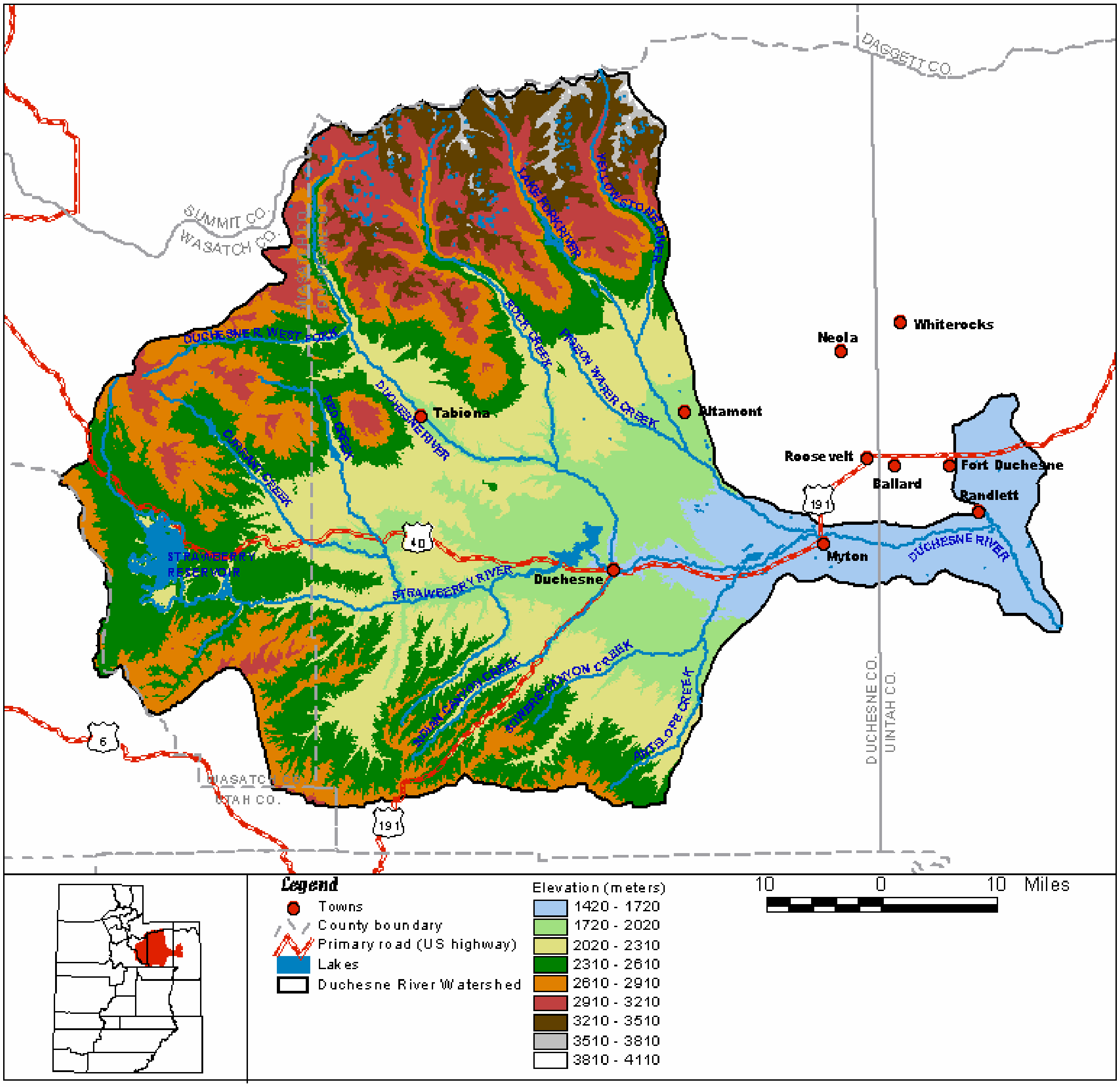

Figure 2-1. Topography in the Duchesne River watershed

2.3 Land Use and Land Cover

This section discusses the available land use and land cover datasets for the Duchesne River watershed.

2.3.1 National Land Cover Dataset

General land use and land cover data for the Duchesne River watershed from the Multi-Resolution Land Characteristics Consortium's National Land Cover Dataset (NLCD) database are shown in Table 2-1 and Figure 2-2. The NLCD was derived from satellite imagery taken during the early 1990s and is the most current detailed land use data known to be available. Each 30-meter by 30-meter pixel contained within the satellite image is classified according to its reflective characteristics. A complete listing and definition of the NLCD land cover categories is given in Appendix B. Table 2-1 summarizes land cover in the Duchesne River watershed and shows that shrubland is the dominant land cover, comprising approximately 46.40 percent of the total area. Evergreen forest and deciduous forest comprise 27.57 percent and 9.33 percent, respectively. Other important cover types include grassland/herbaceous (6.44 percent), bare rock/sand/clay (3.29 percent), mixed forest (3.02 percent), and pasture/hay (2.43 percent). All other individual land cover types comprise less than one percent of the total watershed area.

Table 2-1. Duchesne River watershed land use and land cover

NLCD Land Cover	Area (Hectares)	Area (Acres)	Percent
Shrubland	341,174.7	843,061.1	46.40%
Evergreen forest	202,732.8	500,963.8	27.57%
Deciduous forest	68,585.9	169,479.5	9.33%
Grassland/herbaceous	47,332.0	116,960.0	6.44%
Bare rock/sand/clay	24,166.6	59,716.9	3.29%
Mixed forest	22,181.1	54,810.7	3.02%
Pasture/hay	17,868.1	44,153.1	2.43%
Open water	6,476.7	16,004.2	0.88%
Row crops	2,028.7	5,012.9	0.28%
Commercial/industrial	962.3	2,378.0	0.13%
Perennial ice/snow	904.6	2,235.4	0.12%
Small grains	280.5	693.1	0.04%
Emergent wetlands	279.2	690.0	0.04%
Low intensity residential	193.4	477.9	0.03%
Urban/recreational grasses	42.1	104.0	0.01%
Woody wetlands	39.4	97.4	0.01%
Quarries/strip mines/gravel pits	33.4	82.5	<0.01%
Orchards/vineyard/other	26.0	64.4	<0.01%
Total	**735,307.6**	**1,816,984.7**	**100.00%**

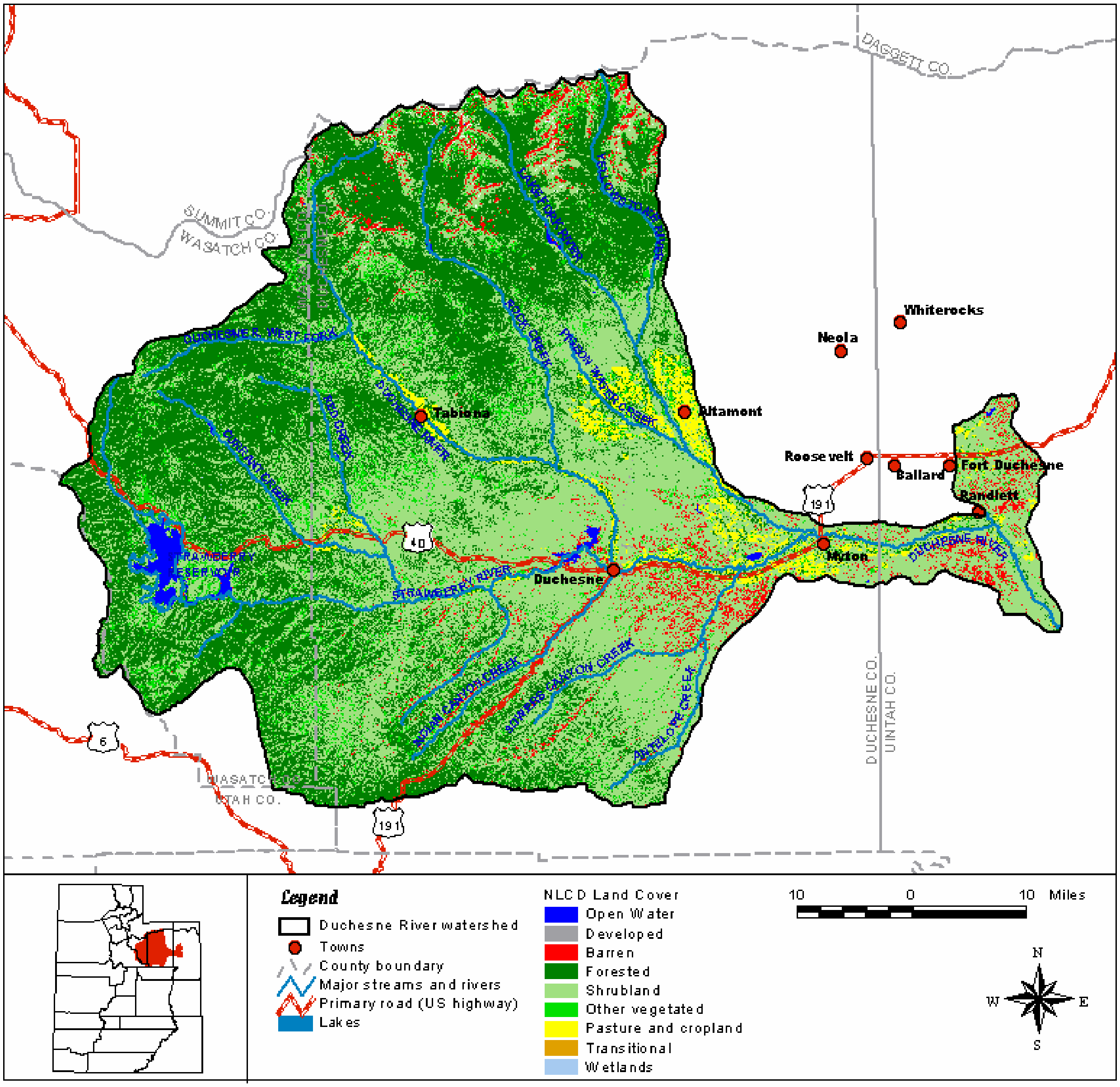

Figure 2-2. Land use and land cover in the Duchesne River watershed

2.3.2 Vegetative Land Cover

Vegetation data were gathered from the Gap Analysis Project (GAP) completed for the state of Utah. The spatial database for Utah is derived from satellite imagery taken during the early 1990s. GAP classifications for the Duchesne River watershed are summarized in Table 2-2 and displayed in Figure 2-3. A description of each vegetation class, including associated land covers, is presented in Appendix C. Sagebrush/perennial grass, pinyon-juniper, aspen, and spruce-fir dominate vegetation in the Duchesne River watershed, accounting for 54.11 percent of total watershed land cover. In addition, sagebrush, salt desert shrub, and agriculture individually contribute greater than 5 percent of the total watershed area and collectively account for approximately 20 percent of all vegetative cover. All remaining land cover classes each comprise less than 5 percent of total watershed area.

Table 2-2. Vegetative land cover in the Duchesne River watershed

Land Use/Land Cover	Area (Hectares)	Area (Acres)	Percent
Sagebrush/perennial grass	127,197.0	314,310.5	17.29%
Pinyon-juniper	105,063.3	259,617.2	14.28%
Aspen	93,464.6	230,956.1	12.70%
Spruce-fir	72,472.7	179,083.9	9.85%
Sagebrush	59,083.5	145,998.6	8.03%
Salt desert scrub	48,937.9	120,928.1	6.65%
Agriculture	36,975.9	91,369.3	5.02%
Pinyon	29,658.5	73,287.8	4.03%
Barren	24,936.0	61,618.2	3.39%
Dry meadow	22,626.6	55,911.6	3.07%
Mountain fir	22,263.4	55,014.0	3.03%
Lodgepole	22,081.7	54,565.1	3.00%
Alpine	19,227.4	47,512.1	2.61%
Juniper	9,367.2	23,146.9	1.27%
Water	6,824.3	16,863.3	0.93%
Desert grassland	6,798.4	16,799.1	0.92%
Ponderosa pine/mountain shrub	6,746.5	16,670.9	0.92%
Mountain shrub	5,890.2	14,555.0	0.80%
Lowland riparian	3,762.5	9,297.2	0.51%
Ponderosa pine	3,425.1	8,463.7	0.47%
Oak	2,439.1	6,027.2	0.33%
Wetland	2,153.7	5,321.9	0.29%
Grassland	1,686.6	4,167.7	0.23%
Mountain riparian	1,323.3	3,270.1	0.18%
Urban	622.8	1,538.9	0.08%
Aspen/conifer	311.4	769.4	0.04%
Wet meadow	181.6	448.8	0.02%
Mountain fir/mountain shrub	181.6	448.8	0.02%
Spruce-fir/mountain shrub	155.7	384.7	0.02%
Total	**735,858.6**	**1,818,346.1**	**100.00%**

Figure 2-3 displays the spatial distribution of vegetative cover in the Duchesne River watershed. It is meant as a general representation of dominant land cover in the watershed and does not identify vegetation associated with each major category. Sagebrush and pinyon-juniper vegetation dominate the middle elevation portions of the watershed and ranges from approximately 1,716 meters (5,630 feet) to 2,016 meters (6,614 feet). Salt desert scrub and desert grassland dominate at lower elevations, starting around 1,500 meters (4,921 feet), and are gradually replaced by sagebrush and pinyon-juniper as the elevation increases. Alpine, spruce-fir, aspen, lodgepole, dry meadow, mountain fir, and ponderosa pine dominate the higher elevation headwaters regions. Agricultural lands are concentrated in the valley floors and account for approximately 36,976 hectares (5.02 percent) of the total watershed.

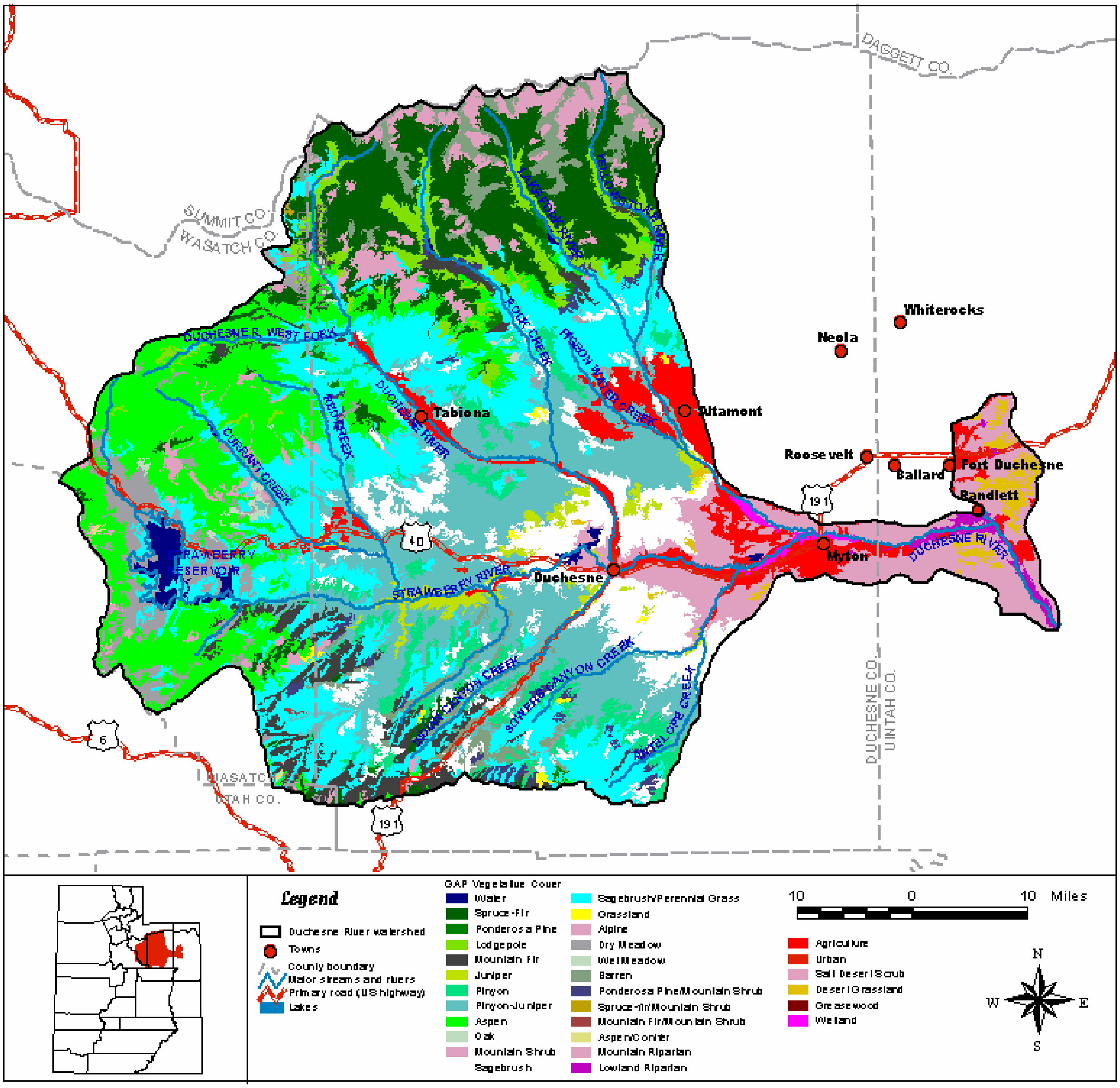

Figure 2-3. Vegetative land cover in the Duchesne River watershed

2.3.3 Water Related Land Use

A detailed spatial database of water related land use is available from the Utah Department of Natural Resources, Division of Water Resources (1995). The database provides information on various land uses associated with water diversion and irrigation practices. Satellite imagery collected in 1991 provides information on typical agricultural crop production and other uses of water within the State of Utah.

The data show that a total of 43,951 hectares (108,607 acres), or approximately 6 percent of the watershed area, were devoted to water related land uses in the Duchesne River watershed. Distinct water related land use types for the watershed and their associated areas are given in Table 2-3.

Table 2-3 and Figure 2-4 show that water related land use is typically located along valley floors and major stream corridors and is predominantly associated with irrigation and reservoir impoundments. Table 2-3 shows that irrigated and non-irrigated lands account for 27,171.6 hectares (61.82 percent) and 5,299.0 hectares (12.06 percent), respectively, of total water related land uses in the watershed. Reservoir impoundment (water) is the second largest category of water related land use types with 10,017.5 hectares (22.79 percent) followed by urban residential with 969 hectares (2.20 percent). Both urban and riparian water related land uses make up less than 1 percent of the total.

Table 2-3. Types of water application in the Duchesne River watershed

Land Use Type	Area (Hectares)	Area (Acres)	Percent
Irrigated	27,171.6	67,142.5	61.82%
Water	10,017.5	24,753.7	22.79%
Non-irrigated	5,299.0	13,094.1	12.06%
Urban residential	969.0	2,394.5	2.20%
Urban	346.0	854.9	0.79%
Riparian	148.7	367.4	0.34%
Total	**43,951.7**	**108,607.1**	**100.00%**

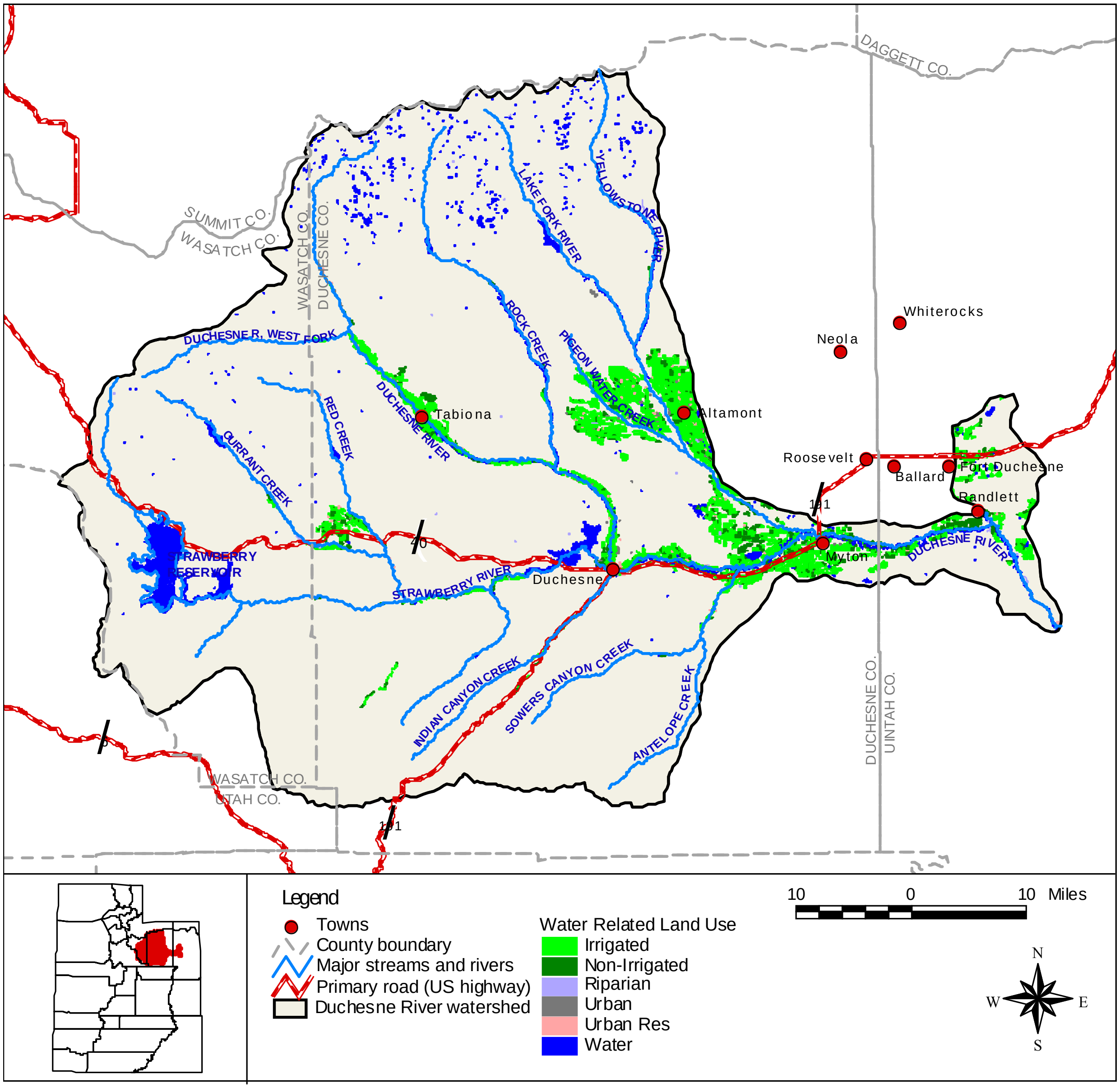

Figure 2-4. Water related land use in the Duchesne River watershed

2.4 Geology and Soils

The Uintah Basin is comprised of three physiographic provinces—Rocky Mountain and Wyoming Basins and the Colorado Plateau (UDEQ, 2005). The Mancos Shale lowlands are within the Colorado Plateau, which are characterized by sloping, gravel covered pediments, rugged badlands, and narrow flat-bottomed alluvial valleys. Due to its chemical composition, exposure, and erodibility, Mancos Shale presents significant natural sources of soluble salts. Mancos Shale contains coal-bearing beds, formed in coastal marine environments. Through mineral dissolution and cation/anion exchange, shale and coal beds are a known contributor of increased TDS in surface and groundwater. Soils are formed in alluvium from mixed sedimentary rocks on foothills, mountain slopes, and alluvial fans. Most soils are well-drained, while some are poorly drained and saline, particularly in the lower portions of the Uintah Basin (UDEQ, 2005).

Soils data and GIS coverages from the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) were used to characterize soils in the Duchesne River watershed. General soils data and map unit delineations are provided as part of the State Soil Geographic (STATSGO) database. GIS coverages provide accurate locations for the soil map units at a scale of 1:250,000 (USDA, 1995). A map unit is composed of several soil series having similar properties. The GIS coverage can provide information on chemical and physical soil characteristics. Because multiple soil series characterize each soil map unit, a weighted sum of soil series parameters was calculated to describe the general properties of each soil map unit. Figure 2-5 shows the general map unit boundaries in the Duchesne River watershed, and the following sections summarize relevant chemical and physical soil data.

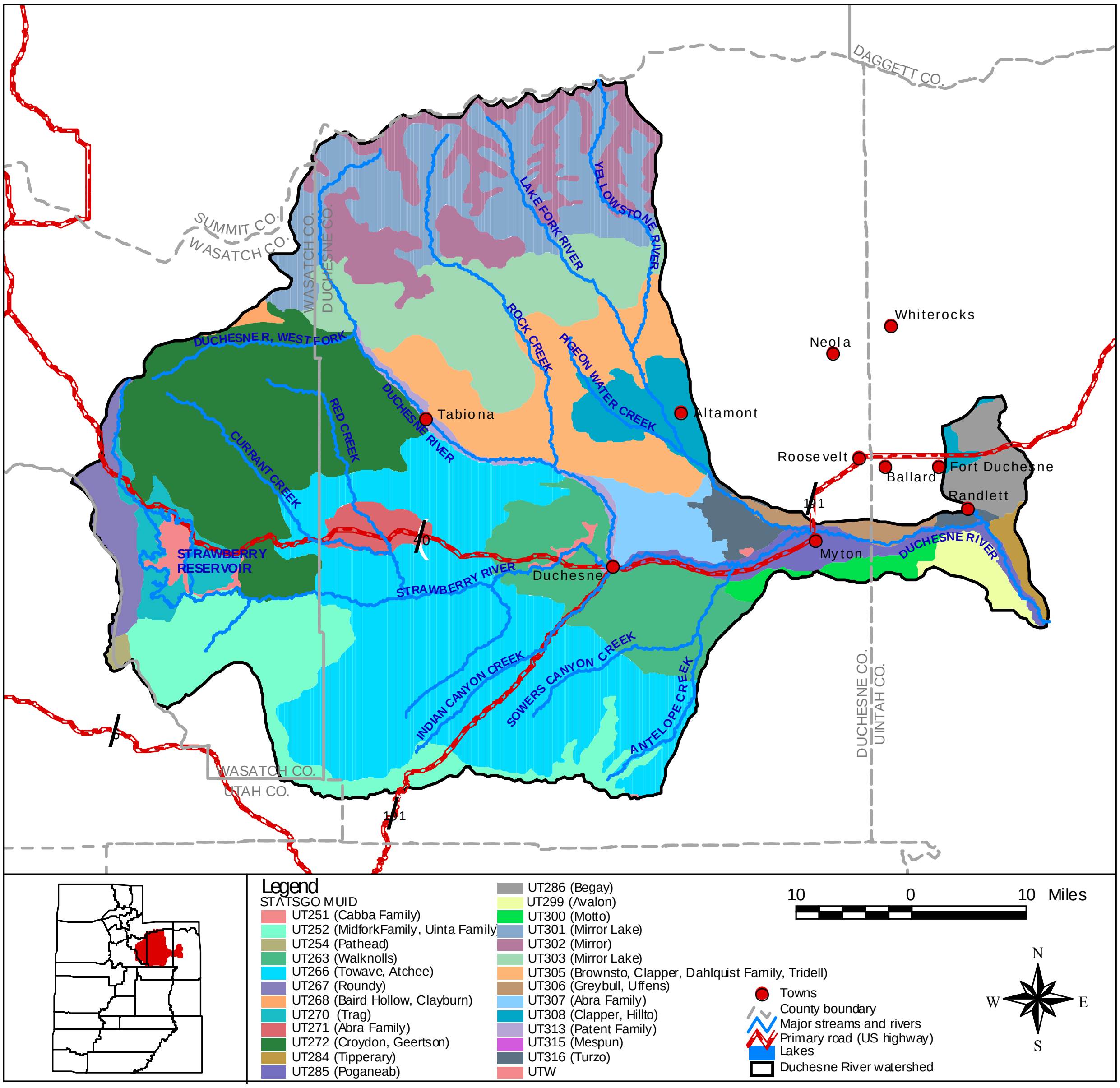

Figure 2-5. General soil map units in the Duchesne River watershed

2.4.1 Hydrologic Soil Group

The hydrologic soil group classification is a means for grouping soils by similar infiltration and runoff characteristics. Clay soils that are poorly drained have lower infiltration rates, while well-drained, sandy soils have higher infiltration rates. NRCS has defined four hydrologic groups for soils (Table 2-4), and data for the Duchesne River watershed were obtained from STATSGO (NRCS, 2001). Data were summarized on the basis of the major hydrologic group in the surface layers of the map unit and are displayed in Figure 2-6.

The weighted sum of hydrologic soil groups for each map unit includes groups B, C, and D. B and C soils dominate the watershed representing 47.69 percent and 44.13 percent of the total area, respectively. Soils in hydrologic group D, around and to the southwest of Starvation Reservoir near the confluence of the Strawberry and Duchesne Rivers, are the least extensive in the watershed, comprising approximately 7.44 percent of total watershed area. These typically have finer texture, which inhibits infiltration.

Table 2-4. Hydrologic soil groups

Hydrologic Soil Group	Description
A	Soils with high infiltrations rates. Usually deep, well-drained sands or gravels. Little runoff.
B	Soils with moderate infiltration rates. Usually moderately deep, moderately well-drained soils.
C	Soils with slow infiltration rates. Soils with finer textures and slow water movement.
D	Soils with very slow infiltration rates. Soils with high-clay content and poor drainage. High amounts of runoff.

2.4.2 Universal Soil Loss Equation (USLE) K-factor

A commonly used soil attribute is the K-factor, a component of the USLE (Wischmeier and Smith, 1978). The K-factor is a dimensionless measure of a soil's natural susceptibility to erosion, and factor values may range from 0 for water surfaces to 1.00 (although in practice, maximum factor values do not generally exceed 0.67). Large K-factor values reflect greater inherent soil erodibility. The distribution of K-factor values in the Duchesne River watershed is shown in Figure 2-7. The figure indicates that soils with moderate erosion potential (e.g., K-factors ranging from 0.20 to 0.37) are limited primarily to the headwaters of the Strawberry River and along the river channel of the Duchesne. These soils comprise approximately 25.43 percent of the soils in the watershed. Figure 2-7 also shows that K-factor values do not exceed 0.32, suggesting that inherent erodibility does not exceed the moderate classification. Low-to-moderate K-factor values dominate the watershed, representing approximately 51 percent of the watersheds soils. Low K-factor values are located in the mountainous regions of the northern part of the watershed and account for approximately 22.72 percent of watershed soils. These low erosion susceptibility areas are typically associated with sandy soils with high infiltration rates.

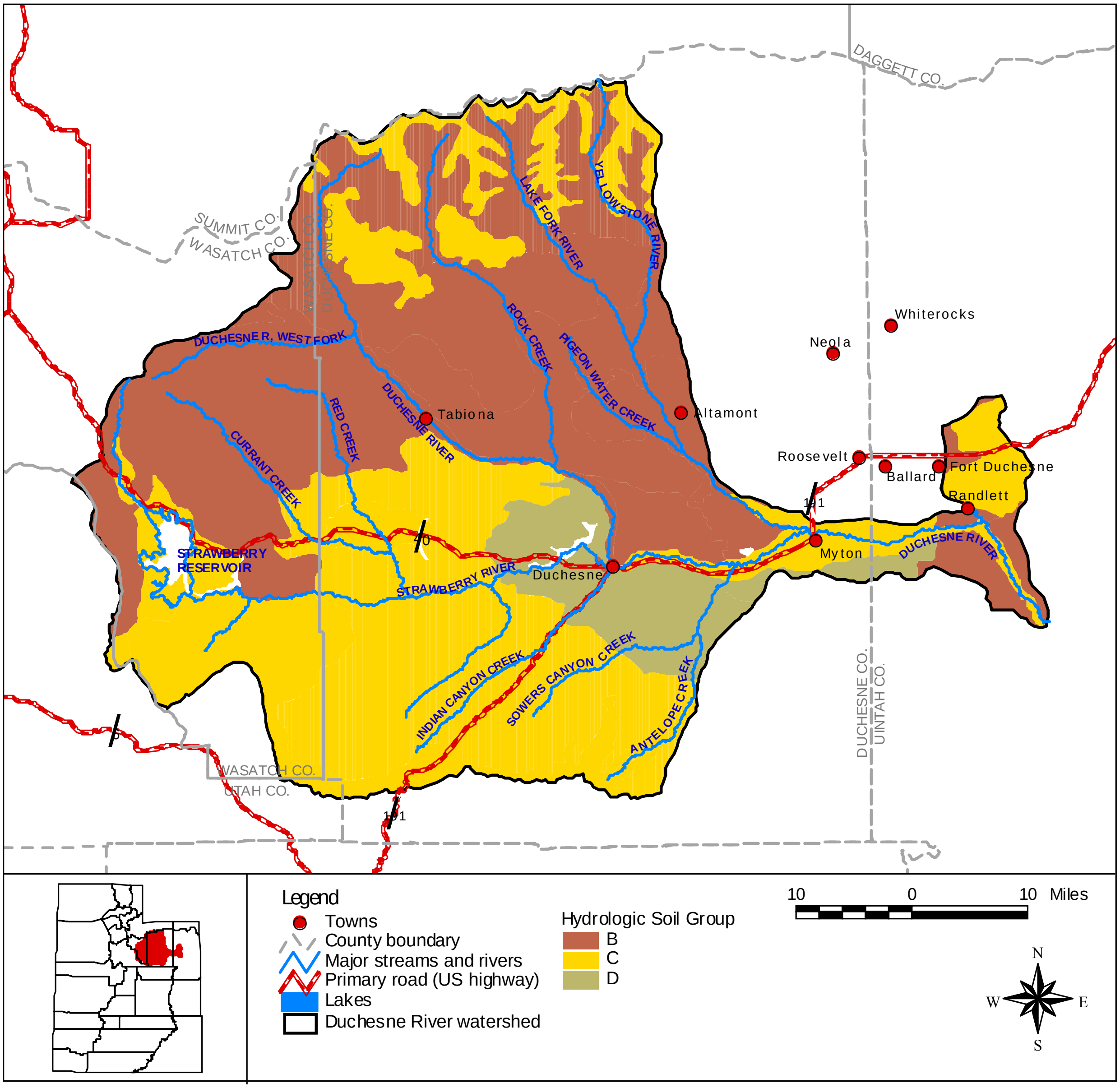

Figure 2-6. Hydrologic soil groups in the Duchesne River watershed

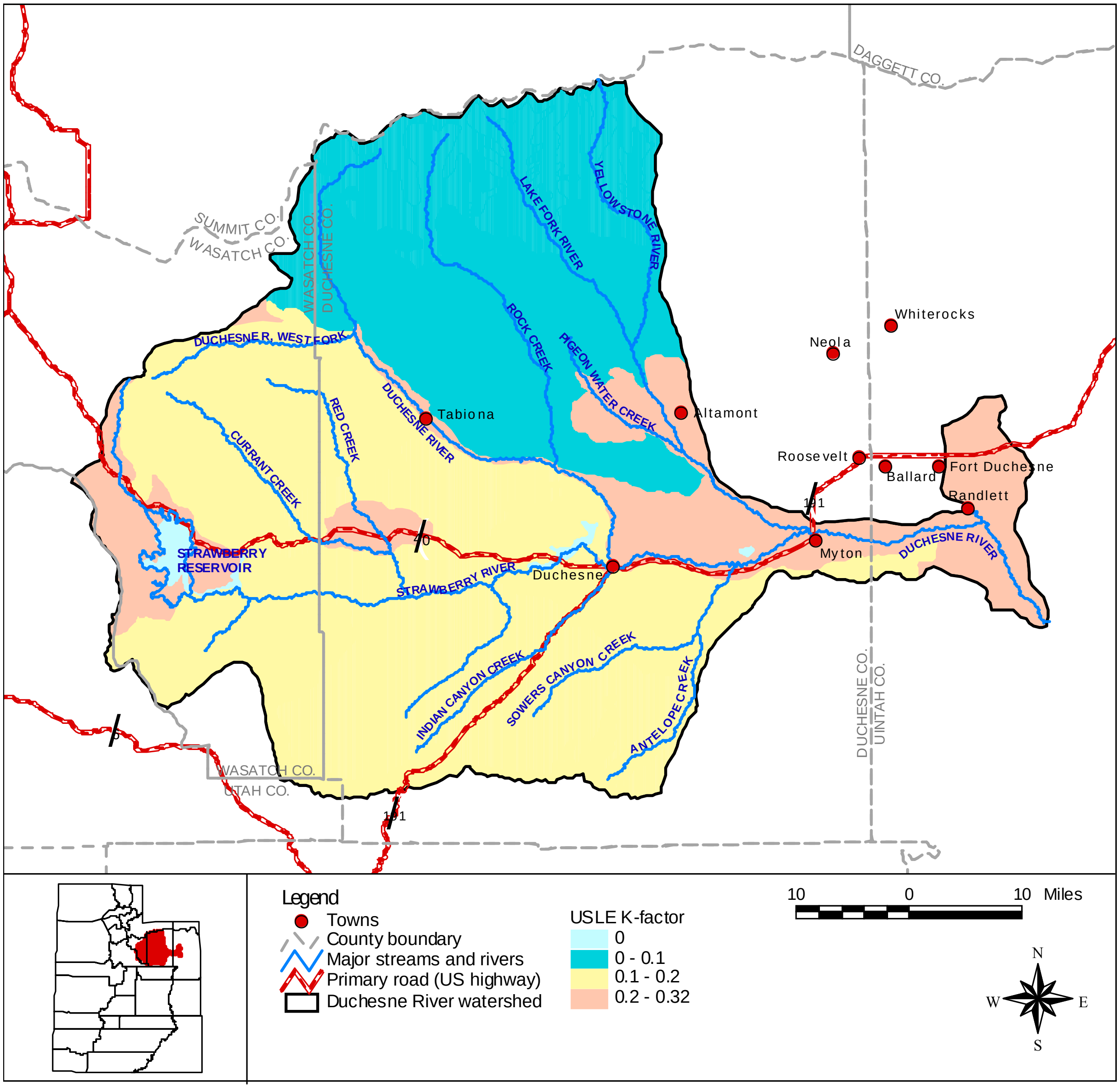

Figure 2-7. USLE K-factors in the Duchesne River watershed

2.4.3 Salinity

Salts naturally occur in the Duchesne River watershed due to saline bedrock materials that are easily weathered. These salts are found in varying concentrations in soils and waters throughout the watershed. In arid regions, salts also accumulate in soils due to evaporation, which concentrates salts in the upper soil layers. The term *salts* refers to several different anions and cations that may be present in solution. The most common salts are calcium, magnesium, sodium, chloride, sulfate, and bicarbonate, and they are usually measured in terms of electrical conductivity or TDS. NRCS classifies saline as having an electrical conductivity greater than 4,000 µS/m. High-salt concentrations in soil can limit the amount of water available to plants and cause plant mortality, but this depends on plant type, soil, and depth of rooting and salts.

Figure 2-8 shows the distribution of soil salt concentrations in the watershed. Data were obtained from the STATSGO database and represent a weighted sum of the average salinity reported for all soil series in the surface layer of a map unit. It should be noted that map units can be highly variable, and Figure 2-8 is meant as a general representation of salinity throughout the watershed. In addition, it is important to note that the STATSGO database salinity values for the following soil map units appear to be significantly incomplete (greater than 50 percent of soil series had no associated data): UT251, UT252, UT254, UT266, UT268, UT272, UT301, UT302, UT303, and UT305. Most of the Duchesne River watershed soils (which did not have significantly incomplete data) had average electrical conductivities between 40 µS/m and 80µS/m. The highest reported electrical conductivities are found along the Duchesne River from the Strawberry River confluence downstream to the Green River confluence. The area of lowest salinity was found in the headwaters of the Yellowstone River and Duchesne River.

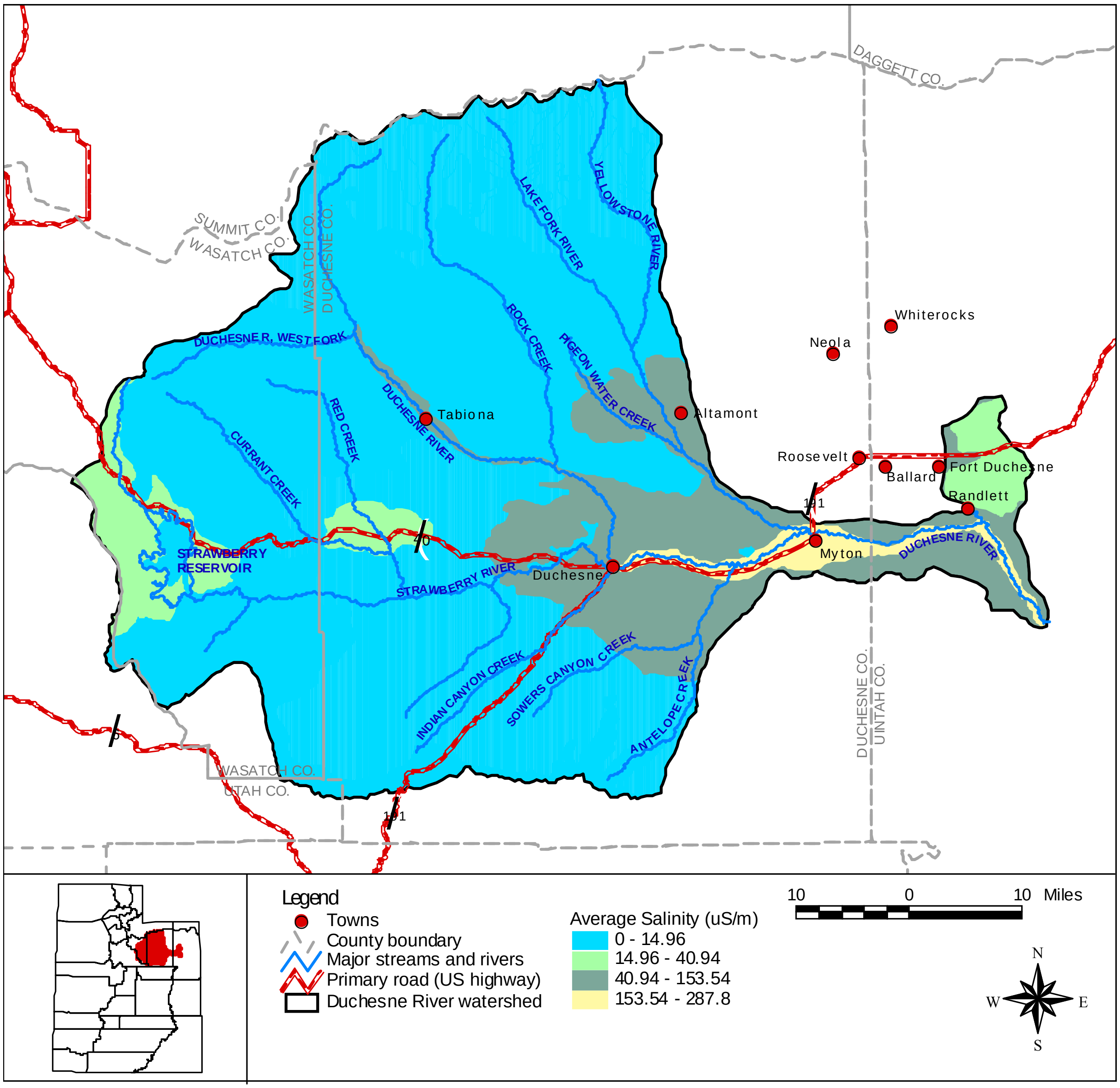

Figure 2-8. Average soil salinity in the Duchesne River watershed

2.4.4 Sodium Adsorption Ratio

Sodium salts are naturally occurring in the Duchesne River watershed due to sodium-rich bedrock in certain areas. These salts make their way into soils through weathering processes and water transport. Due to evaporation, sodium tends to accumulate in the soil surface layers and can have adverse effects on vegetation. High sodium concentrations can disperse clay soils, changing the soil structure and rendering the soil hard and resistant to water infiltration and aeration. Sodium is also toxic to plants at elevated concentrations and raises soil pH, which can also be toxic to plants.

Calcium and magnesium in the soil solution help to mitigate the effects of high sodium concentrations on soil structure. Because of this, a sodium adsorption ratio (SAR) is often used to determine the potential for sodium-caused impairment. The SAR is a ratio of sodium (Na) to calcium (Ca) and magnesium (Mg) in the soil solution, as follows

$$SAR = \frac{Na}{\sqrt{\frac{1}{2}\left(Ca + Mg\right)}}.$$

The degree at which sodium affects soils and crops varies with a number of factors, including precipitation, soil type, amount of clay, salinity, and crop type. It is generally recommended that irrigation waters should have a SAR less than 10.

Figure 2-9 shows the distribution of soil SAR values in the Duchesne River watershed. Data were obtained from the STATSGO database and represent the weighted sum of the average SAR reported for all soil series in the surface layer of a map unit. It should be noted that map units can be highly variable, and Figure 2-9 is meant as a general representation of the SAR throughout the watershed. The highest ratios are in the areas downstream of the Strawberry River–Duchesne River confluence, while the majority of the watershed has SAR values of 0.

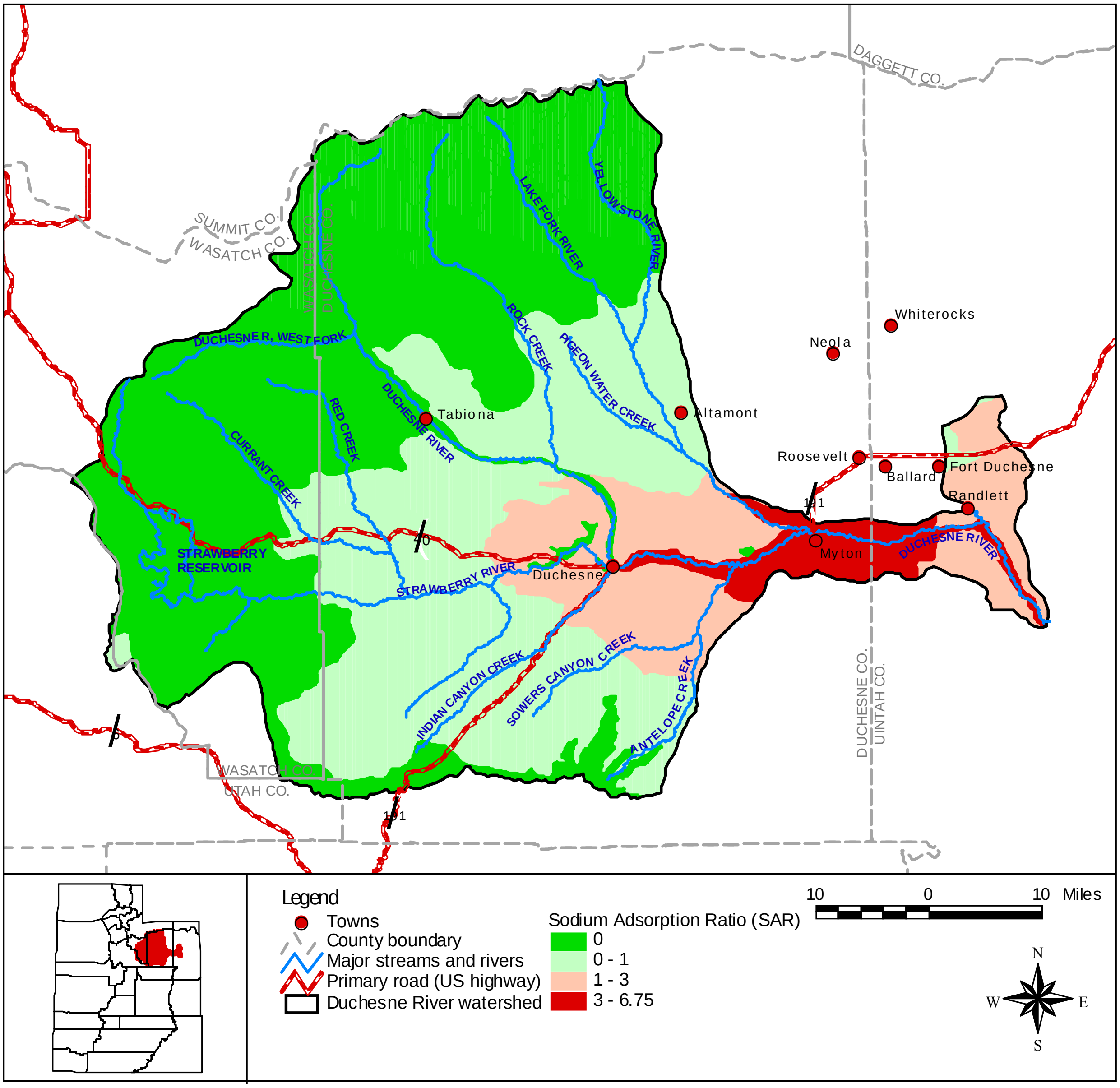

Figure 2-9. Average soil SAR values in the Duchesne River watershed

2.4.5 Clay Content

The clay content of a soil affects the soil in many ways. Structure, texture, water holding capacity, and the mineral content of clay all help define the potential land uses of a soil type. In the Duchesne River watershed, clay content of the soil ranges from 7 to 30 percent (Figure 2-10). Data for Figure 2-10 were obtained from the STATSGO database and represent the weighted sum of the average clay content reported for all soil series in the surface layer of a map unit. It should be noted that map units can be highly variable, and Figure 2-10 is meant as a general representation of the clay content throughout the watershed.

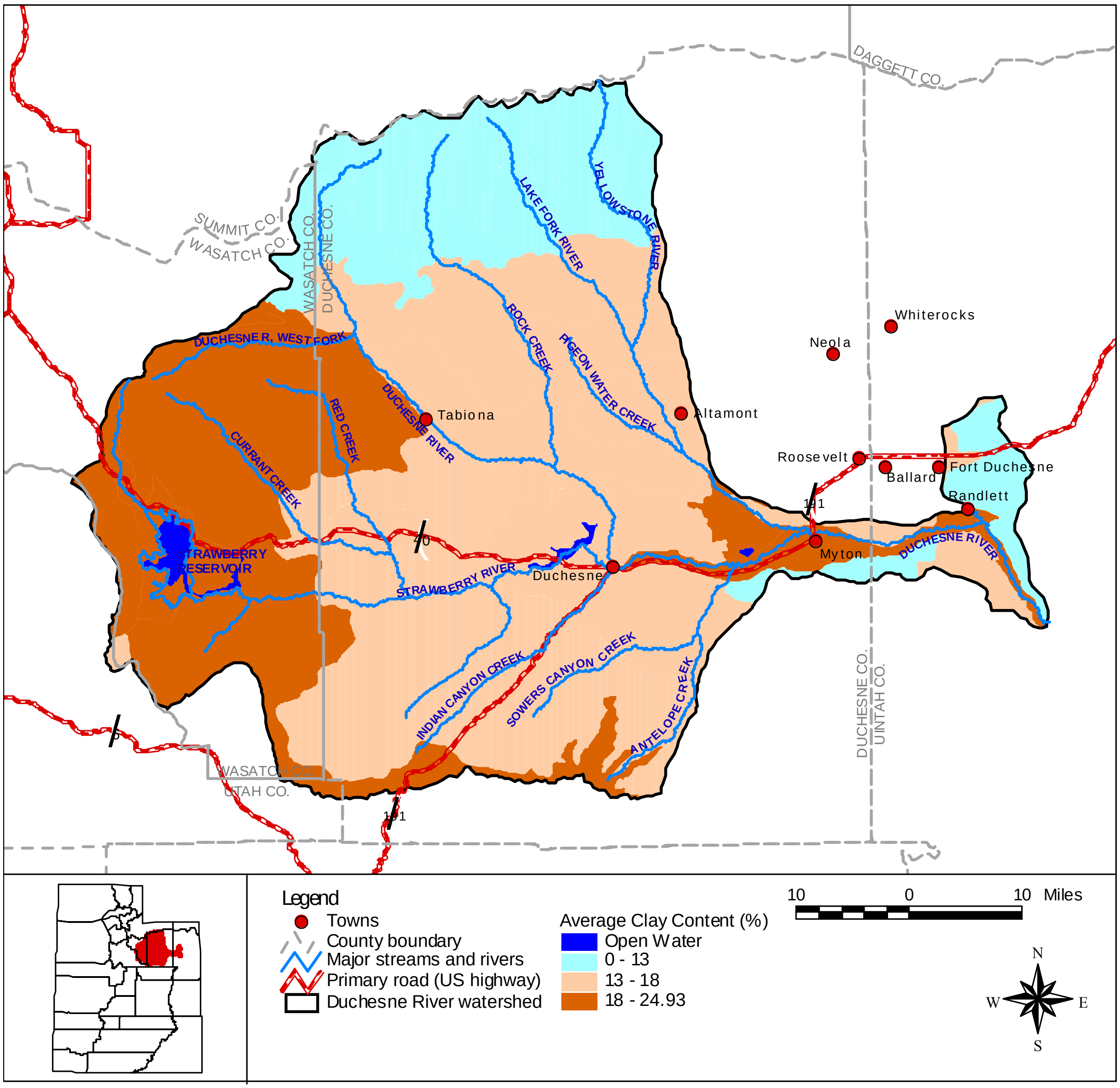

Figure 2-10. Average soil clay content in the Duchesne River watershed

2.5 Land Ownership

Land ownership information was digitized for the U.S. Fish and Wildlife Utah GAP analysis and is available for the entire state of Utah. This dataset describes general land management units as well as enclaves of land ownership within each management unit. Various federal, state, private, and tribal agencies are responsible for managing land throughout the Duchesne River watershed (Figure 2-11; Table 2-5). The U.S. Forest Service (USFS) is responsible for managing 300,542.7 hectares (40.87 percent), while private landowners manage 229,397.0 hectares (31.20 percent). Other landowners and managers include Native Americans, the State of Utah, the Bureau of Land Management (BLM), and the Bureau of Reclamation (BOR).

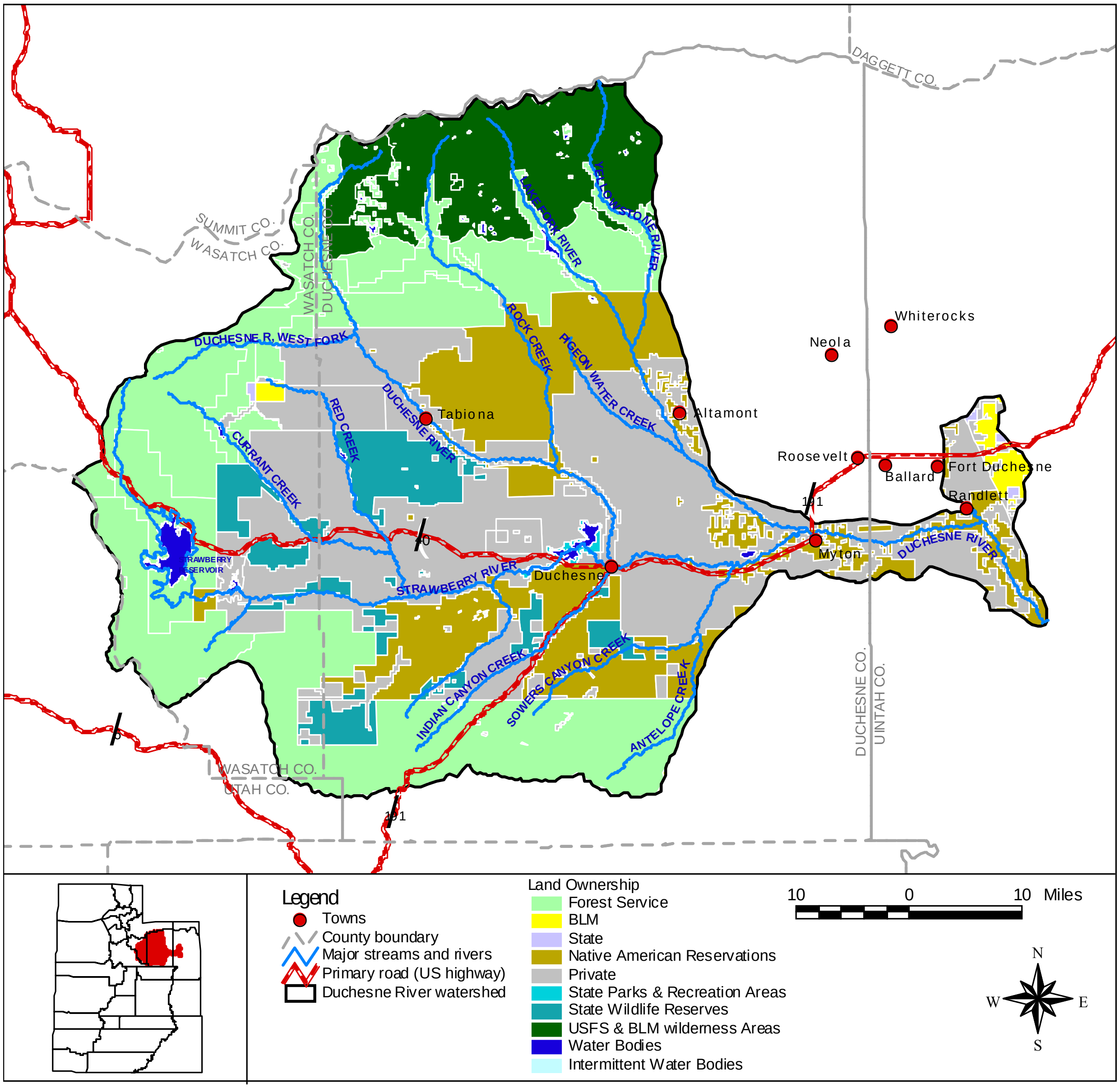

Figure 2-11. Land ownership in the Duchesne River watershed

Table 2-5. General land management units in the Duchesne River watershed

Land Management Units	Area (Hectares)	Area (Acres)	Percent
USFS	300,542.7	742,657.1	40.87%
Private	229,397.0	566,852.4	31.20%
Native American Reservations	122,762.5	303,352.7	16.70%
State	43,940.9	108,580.3	5.98%
USFS/BOR	13,479.7	33,309.0	1.83%
Private/USFS	12,305.9	30,408.6	1.67%
Water	6,337.1	15,659.2	0.86%
BLM	4,990.6	12,331.9	0.68%
Private/BOR/USFS	1,146.9	2,834.1	0.16%
State/USFS	307.1	758.9	0.04%
Intermittent water	48.1	118.9	0.01%
BLM/BOR	46.0	113.6	0.01%
Total	**735,304.4**	**1,816,976.8**	**100.00%**

2.6 Climate

Climate within the Uintah Basin varies with changes in topography. Average annual precipitation throughout the Uintah Basin totals approximately 8.5 inches, but varies greatly with elevation and location relative to the mountain ranges that border to the west and north. Average annual precipitation varies from less than 7 inches near Ouray at the Duchesne River–Green River confluence to about 40 inches in the adjacent Uinta Mountains. Snowfall characterizes winter precipitation, while thunderstorms dominate during the summer season when a northerly flow of warm, moist air from the Gulf of Mexico prevails. The Uinta Basin gets little precipitation from frontal systems coming from the northwest or west because fronts weaken as they descend the slopes of the Wasatch Range or the Uinta Mountains.

Daily temperature extremes can vary as much as 40 degrees. Annual extreme temperatures range from -30° to 105°F. The basin averages between 80 and 160 frost-free days a year while much of the Uinta Mountains have fewer than 40 days free of frost. The average frost-free period is 115 days at Duchesne and 125 days at Roosevelt.

A distribution of annual average precipitation in the Duchesne River watershed is available from the NRCS, Water and Climate Center (NRCS, 1998). The NRCS climate dataset is a continuous distribution of average annual precipitation interpolated from precipitation measurements made at local climate stations. This interpolation method, Parameter-elevation Regressions on Independent Slope (PRISM), uses precipitation measurements and Digital Elevation Models (DEMs) to generate a gridded estimate of precipitation that incorporates spatial scale and the effects of elevation on precipitation. Precipitation distribution estimates and elevation are presented in Figure 2-12.

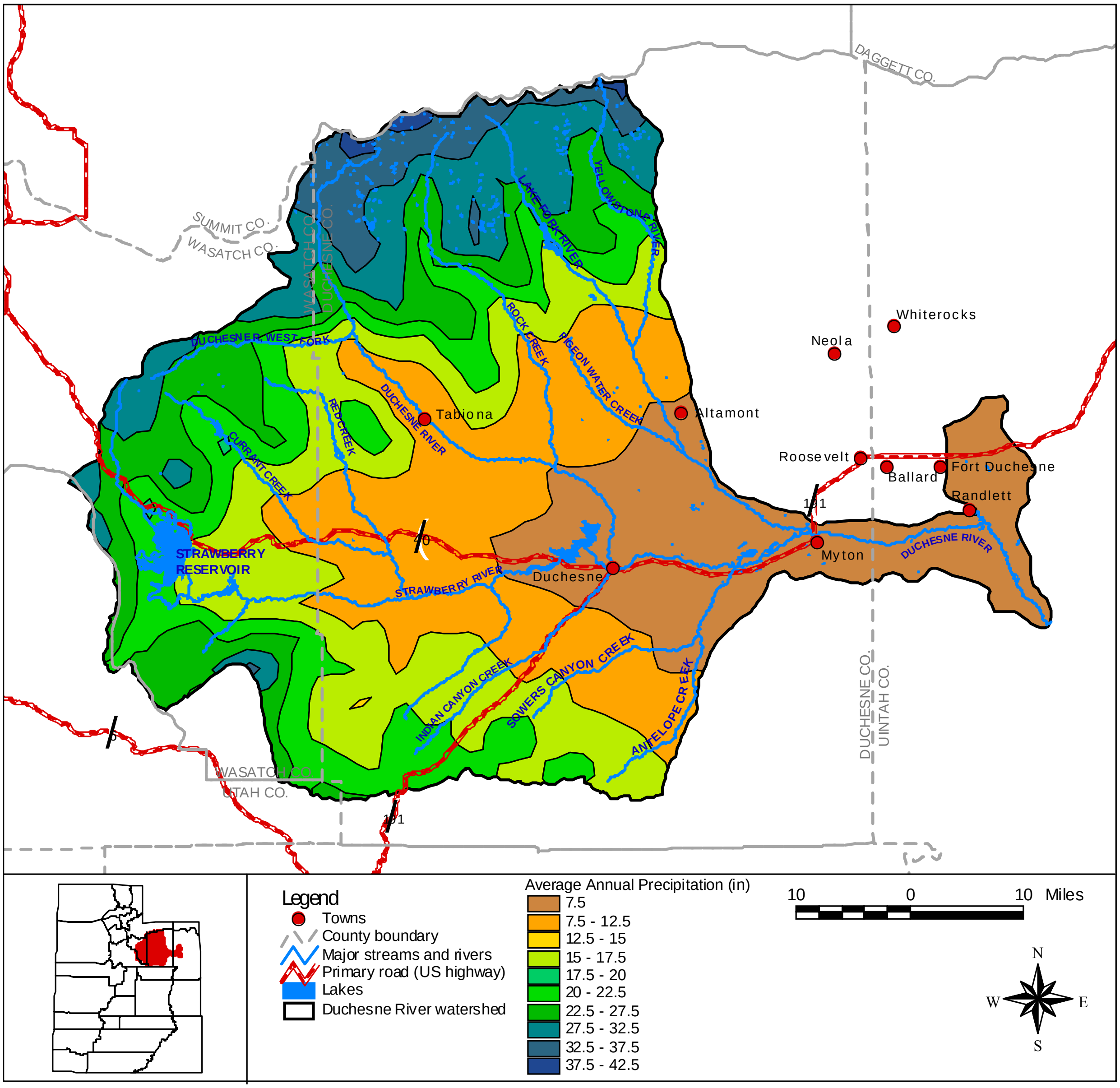

Figure 2-12. Annual average precipitation in the Duchesne River watershed

2.7 Watershed Hydrology

The hydrology of the Uintah Basin is dominated by spring runoff and from brief, intense storms that occur in late summer. Several large reservoirs in the basin have altered the natural hydrology of these major rivers by reducing spring peak and providing higher minimum flows during summer and winter months. Water diversions for agricultural, municipal, and industrial uses have also altered the natural hydrology of the basin by reducing instream flows below diversion points (BLM, 2005). This section discusses the variety of stream types and water uses in the Duchesne River watershed.

2.7.1 Stream Types

The National Hydrography Dataset, created by the EPA and the USGS, indicate six different stream types in the Duchesne River watershed (Figure 2-13). Most of the streams were classified as intermittent streams (Table 2-6). Intermittent streams have flow only for short periods during the course of a year, and flow events are usually initiated by rainfall. Perennial stream flow was classified predominantly in the mainstems of rivers and streams (Figure 2-13). In addition, headwaters at higher elevations have perennial flow due to snowmelt and precipitation, while streams at lower elevations are generally intermittent and flow only after local rainstorms. For example, in dry years, groundwater flow is the primary source of flow in Indian Canyon Creek and Antelope Creek. Most of the canals, ditches, connectors, and pipelines are along perennial streams and rivers throughout the watershed to utilize snowmelt and precipitation for irrigated crop production.

Table 2-6. Summary of stream type in the Duchesne River watershed

Stream Type	Stream Length (km)	Percent
Intermittent stream/river	4167.9	57.56%
Perennial stream/river	2005.1	27.69%
Canal/ditch	930.5	12.85%
Artificial path	106.4	1.47%
Connector	18.7	0.26%
Underground pipeline	12.0	0.17%
Total	**7240.7**	**100.00%**

2.7.2 Flow Data

The USGS National Water Information System (NWIS) online database lists 57 flow gauges with current and historic flow data in the Duchesne River watershed (Figure 2-14 and Table 2-7). Flow at all gauges in the Duchesne River watershed is affected by precipitation, evaporation, groundwater, irrigation, and water withdrawals. Figure 2-15 illustrates the different flow patterns and magnitudes throughout the watershed with average daily flows (for 1998–2003) on the Duchesne River (at confluence with Uinta River and upstream West Fork), Yellowstone River, Lake Fork River and Strawberry River.

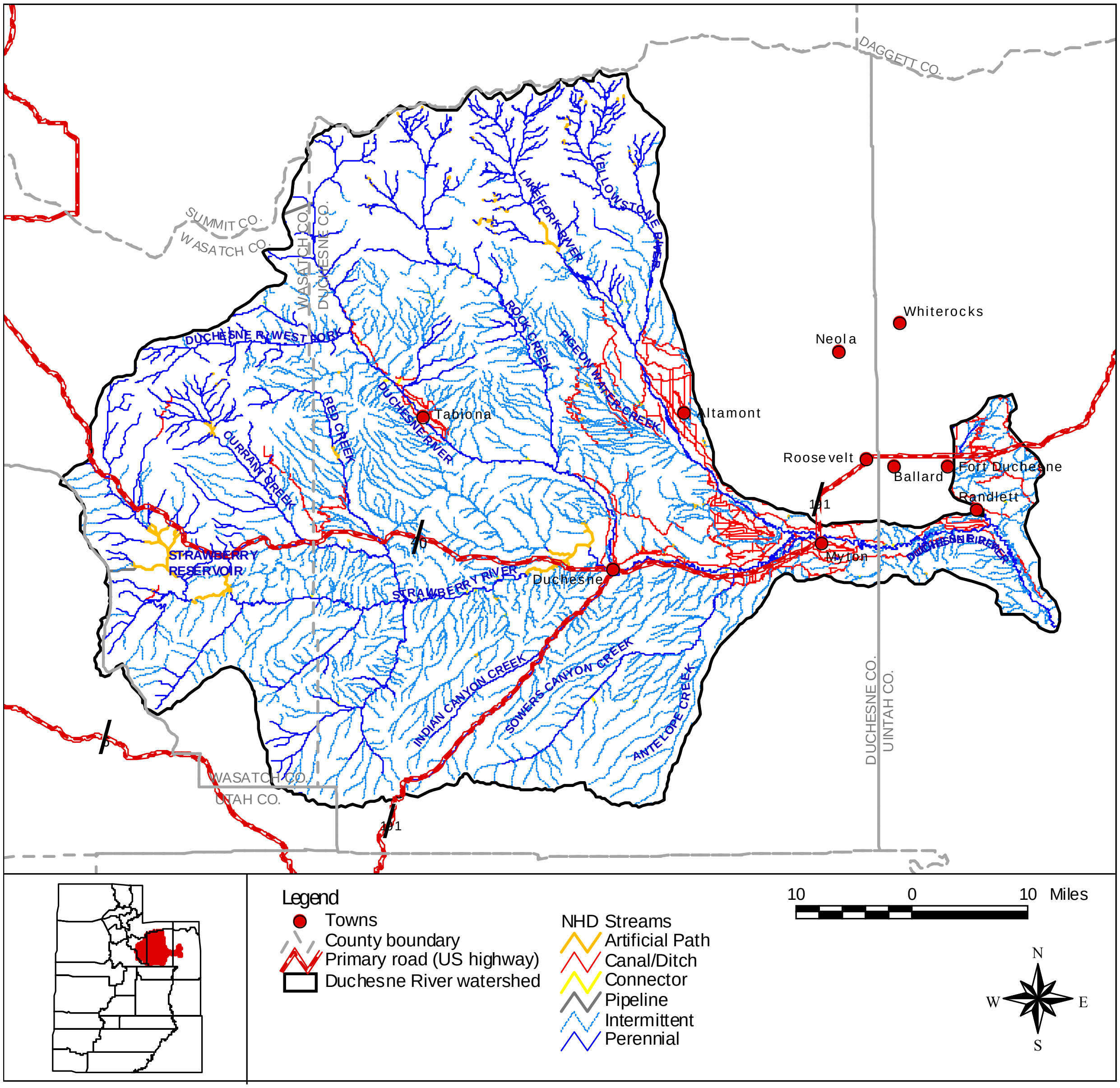

Figure 2-13. Stream types in the Duchesne River watershed

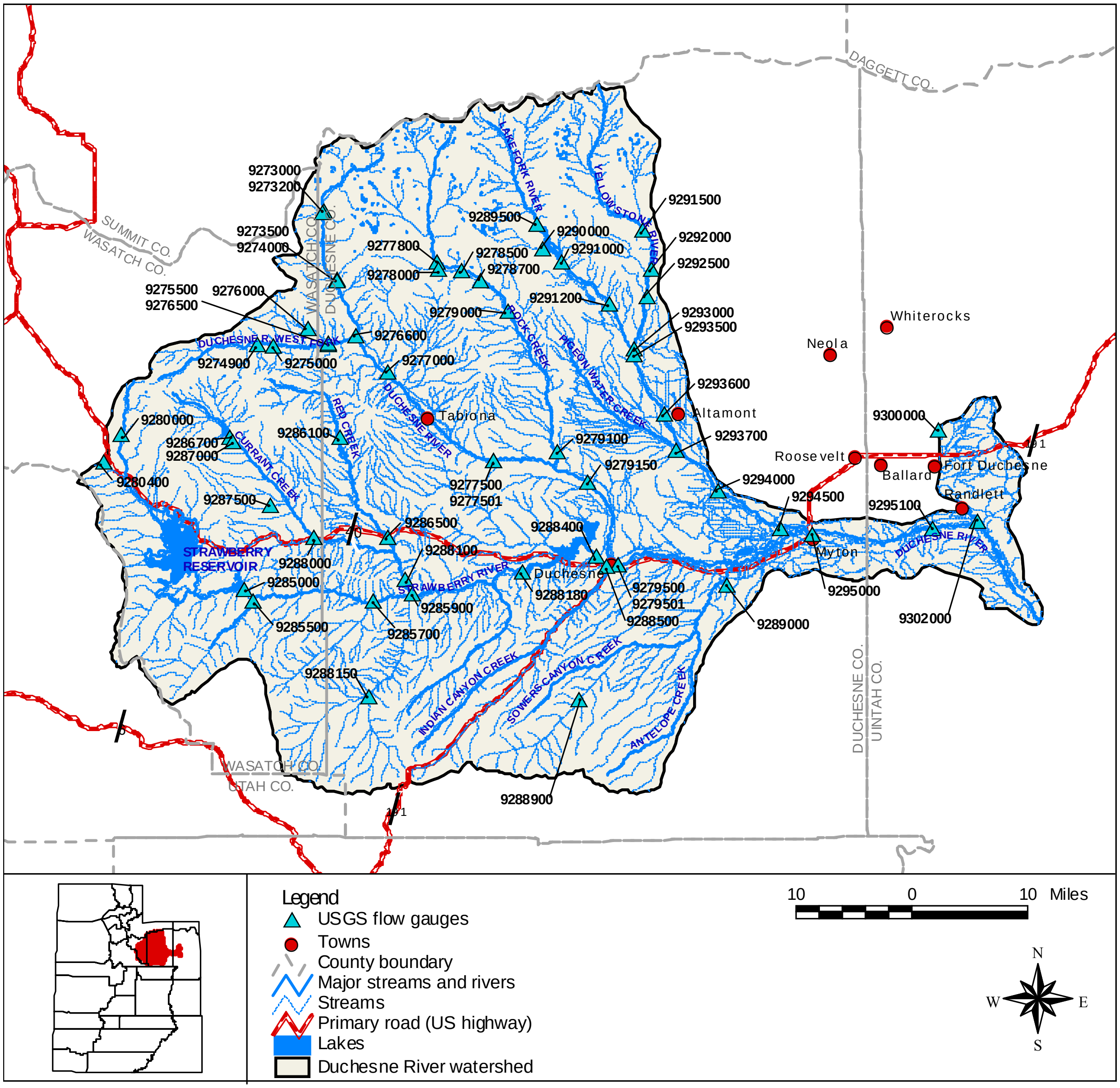

Figure 2-14. USGS flow station locations in the Duchesne River watershed

Table 2-7. USGS stream gauges in the Duchesne River watershed

Station ID	Station Name	Start Date	End Date	Drainage Area (Hectares)	(Acres)
9273000	Duchesne R at Provo R Trail near Hanna, Utah	7/1/1929	9/30/1954	10,101	24,960
9273200	Duchesne R Below LT Deer Cr near Hanna, Utah	10/1/1964	9/30/1968	10,101	24,960
9273500	Hades Cr near Hanna, Utah	9/1/1949	9/30/1968	1,942	4,800
9274000	N.F. Duchesne R near Hanna, Utah	8/16/1921	9/30/1963	20,202	49,920
9274900	W.F. Duchesne R below Vat diversion near Hanna, Utah	10/1/1989	9/30/1994	10,360	25,600
9275000	W.F. Duchesne R below Dry Hollow near Hanna, Utah	9/1/1949	10/6/1981	11,344	28,032
9275500	W.F. Duchesne R near Hanna, Utah	9/1/1921	9/30/1994	15,954	39,424
9276000	Wolf Cr above Rhoades Canyon near Hanna, Utah	10/1/1945	9/30/1984	2,745	6,784
9276500	Wolf Cr near Hanna, Utah	9/1/1921	9/30/1923	4,921	12,160
9276600	W.F. Duchesne R Above N.F. near Hanna, Utah	10/1/1989	9/30/2003	21,497	53,120
9277000	Duchesne R at 'The Point' at Hanna, Utah	8/1/1953	9/30/1960	59,570	147,200
9277500	Duchesne R near Tabiona, Utah	10/1/1918	9/30/2003	91,427	225,920
9277501	COM FL Duchesne R and Duchesne Tunnel near Tabiona, Utah	10/1/1918	9/30/1967	92,203	227,840
9277800	Rock Cr above S.F. near Hanna, Utah	10/1/1965	10/3/1994	25,615	63,296
9278000	S.F. Rock Cr near Hanna, Utah	8/1/1953	10/13/1992	4,066	10,048
9278500	Rock Cr near Hanna, Utah	8/1/1949	9/30/1988	31,598	78,080
9278700	Rock Cr below Miners Gulch near Hanna, Utah	8/14/1974	10/7/1981	34,447	85,120
9279000	Rock Cr near Mountain Home, Utah	10/1/1937	9/30/2003	38,073	94,080
9279100	Rock Cr near Talmage, Utah	10/1/1963	9/30/1994	61,642	152,320
9279150	Duchesne R above Knight Diversion near Duchesne, Utah	4/1/1970	9/30/2003	161,356	398,720
9279500	Duchesne R at Duchesne, Utah	10/1/1917	4/30/1970	170,939	422,400
9279501	COM FL Duchesne R and Duchesne Tunnel at Duchesne, Utah	10/1/1917	9/30/1967	170,939	422,400
9280000	Strawberry R and Willow Cr Ditches near Heber, Utah	9/16/1949	9/30/1960	N/A	N/A
9280400	Hobble Cr at Daniels Summit near Wallsburg, Utah	10/1/1963	9/30/1984	749	1,850
9285000	Strawberry R near Soldier Springs, Utah	10/1/1942	9/30/1994	55,167	136,320
9285500	Willow Cr near Soldier Springs, Utah	5/11/1943	9/30/1947	11,396	28,160
9285700	Strawberry R above Red Cr near Fruitland, Utah	10/1/1963	10/28/1981	94,017	232,320
9285900	Strawberry R at Pinnacles near Fruitland, Utah	10/1/1989	10/3/1994	98,420	243,200
9286100	Red Cr above Reservoir near Fruitland, Utah	10/1/1986	9/30/1998	8,133	20,096
9286500	Red Cr near Fruitland, Utah	11/23/1917	9/30/1961	23,051	56,960

Station ID	Station Name	Start Date	End Date	Drainage Area (Hectares)	(Acres)
9286700	Currant Cr below Currant Cr Dam, near Fruitland, Utah	10/1/1983	10/2/1994	12,432	30,720
9287000	Currant Cr below Red Ledge Hollow near Fruitland, Utah	10/1/1945	10/12/1983	12,976	32,064
9287500	Water Hollow near Fruitland, Utah	4/20/1946	9/30/1984	3,574	8,832
9288000	Currant Cr near Fruitland, Utah	1/1/1935	9/30/2003	36,260	89,600
9288100	Red Cr below Currant Cr, near Fruitland, Utah	10/1/1963	10/28/1981	76,923	190,080
9288150	W. .F Avintaquin Cr near Fruitland, Utah	6/1/1964	9/30/1986	14,530	35,904
9288180	Strawberry R near Duchesne, Utah	5/1/1968	9/30/2003	237,502	586,880
9288400	Strawberry R below Starvation Reservoir near Duchesne, Utah	6/1/1989	10/3/1994	274,280	677,760
9288500	Strawberry R at Duchesne, Utah	4/1/1914	9/30/1968	276,093	682,240
9288900	Sowers Cr near Duchesne, Utah	6/1/1964	9/30/1986	10,515	25,984
9289000	Antelope Cr near Myton, Utah	11/25/1917	7/15/1921	51,282	126,720
9289500	Lake Fork R at Moon Lake, near Mountain Home, Utah	5/1/1933	9/30/2003	20,176	49,856
9290000	Brown Duck Cr near Mountain Home, Utah	4/14/1933	9/30/1955	N/A	N/A
9291000	Lake Fork R below Moon Lake near Mountain Home, Utah	4/1/1942	9/30/2003	29,008	71,680
9291200	Lake Fork R below Taskeech dam site near Mountain Home, Utah	10/1/1976	9/30/1984	35,742	88,320
9291500	Yellowstone Cr below Swift Cr near Altonah, Utah	8/28/1949	9/30/1955	25,641	63,360
9292000	Yellowstone R at Bridge Campground near Altonah, Utah	8/6/1996	9/30/2003	29,526	72,960
9292500	Yellowstone R near Altonah, Utah	10/1/1944	9/30/2003	34,188	84,480
9293000	Yellowstone R at Mouth near Altonah, Utah	4/27/1943	10/7/1981	36,778	90,880
9293500	Lake Fork R near Altonah, Utah	8/31/1976	10/7/1981	78,736	194,560
9293600	Lake Fork R near Altonah, Utah	8/31/1976	10/7/1981	82,362	203,520
9293700	Pigeon Water Cr near Altamont, Utah	8/31/1976	10/4/1979	24,734	61,120
9294000	Lake Fork R near Upalco, Utah	10/1/1942	10/7/1981	110,593	273,280
9294500	Lake Fork R near Myton, Utah	3/1/1910	10/7/1981	125,355	309,760
9295000	Duchesne R at Myton, Utah	3/12/1910	9/30/2003	684,534	1,691,520
9295100	Duchesne R above Uinta R near Randlett, Utah	3/26/1998	9/30/2003	1,096,860	2,710,400
9302000	Duchesne R near Randlett, Utah	10/1/1942	9/30/2003	1,099,968	2,718,080
9273000	Duchesne R at Provo R Trail near Hanna, Utah	7/1/1929	9/30/1954	10,101	24,960

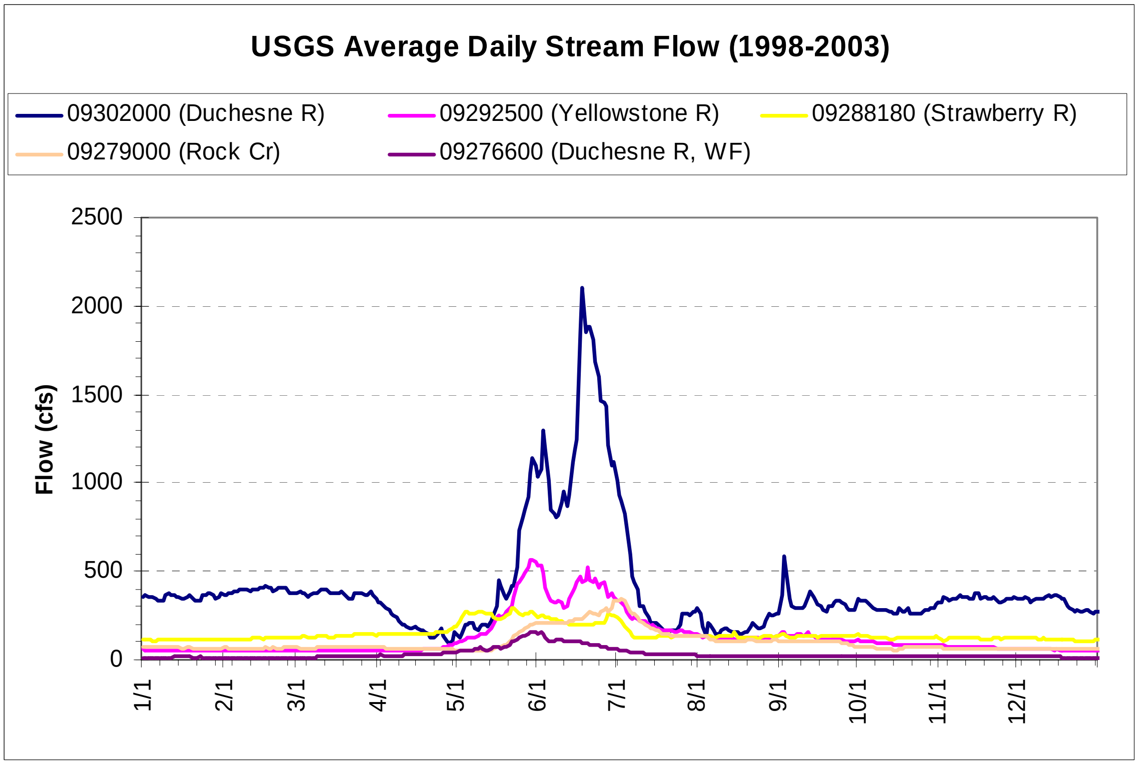

Figure 2-15. Average daily flow at five stations in the Duchesne River watershed

2.8 Water Supply and Uses

Sprinkler irrigation has been an important part of Utah's agricultural production since the early 1950s. Approximately 40 percent of Utah's 1.3 million irrigated acres are watered with sprinklers (Utah State University, 2002). Agricultural irrigation diverts approximately 797,610 acre-feet of water annually in the Uintah Basin, municipal and industrial uses divert 21,430 acre-feet, and 2,500 acre-feet are diverted for secondary contact water use (Utah State University, 2002). The potential average annual trans-basin diversions from the Uinta Basin to the Wasatch Front include the Strawberry Collection System (101,900 acre-feet), Strawberry Water Users (61,500 acre-feet), and the Duchesne Tunnel (31,700 acre-feet). The total of these diversions is greater than the developed supply because water (primarily agricultural water) is rediverted and reused as it moves through the river system. Groundwater is also used for municipal, industrial, and agricultural purposes (UDEQ, 2005).

3. WATER QUALITY STANDARDS AND TMDL TARGET

The goal of a TMDL is to restore designated beneficial uses by attaining and maintaining water quality standards. One of the primary components of a TMDL is the establishment of an instream numeric target to evaluate the attainment of acceptable water quality. Instream numeric targets, therefore, represent the water quality goals to be achieved by implementing the load reductions specified in the TMDL. The targets allow for a comparison between instream conditions and conditions that are expected to restore designated uses. The targets are established on the basis of numeric or narrative criteria from state water quality standards. If applicable numeric water quality standards are available, they can serve as a TMDL target. If only narrative criteria are available, a numeric target is developed to represent conditions resulting in the attainment of designated beneficial uses.

3.1 Water Quality Standards

Under the Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation’s surface waters. These standards represent a level of water quality that will support the Clean Water Act’s goal of “swimmable/fishable” waters. Water quality standards consist of three different components:

- **Beneficial uses** reflect how the water can potentially be used by humans and how well it supports a biological community. Beneficial uses include drinking water supply, recreation, aquatic life support and agriculture.

- Criteria express the condition of the water that is necessary to support the beneficial uses. **Numeric criteria** represent the concentration limit of a pollutant that can be in the water and still support the beneficial use of the waterbody. **Narrative criteria** are the general water quality criteria that apply to all surface waters. These criteria state that all waters must be free from sludge; floating debris; oil and scum; color- and odor-producing materials; substances that are harmful to human, animal or aquatic life; and nutrients in concentrations that may cause algal blooms.

- The **antidegradation policy** establishes situations under which the state may allow new or increased discharges of pollutants and requires those seeking to discharge additional pollutants to demonstrate an important social or economic need.

Table 3-1 presents the Utah Standards Segments and Use Classes for each of the 303(d) listed segments in the Duchesne River watershed.

Table 3-1. Classification of impaired waters in the Duchesne River watershed

Standards Segment Unit ID	Standards Segment	Use Classes
UT14060003-001	Duchesne River and tributaries from the confluence with the Green River to Myton Water Treatment Plant intake	2B, 3B, 4
UT14060003-002	Duchesne River and tributaries from Myton Water Treatment Plant intake to headwaters	1C, 2B, 3A, 4
UT14060003-008	Lake Fork River and tributaries from confluence with the Duchesne River to headwaters	1C, 2B, 3A, 4

1C—protected for domestic uses with prior treatment by treatment processes as required by drinking water
2B—protected for secondary contact recreation such as boating, wading, or similar uses.
3A—protected for cold water species of game fish and other cold water aquatic life, including the organisms in their food chain
3B—protected for warm water species of game fish and other warm water aquatic life, including organisms in their food chain
4—protected for agricultural uses including irrigation of crops and stock watering

The Duchesne River watershed is part of the larger Colorado River Basin, which provides irrigation water for nearly 4 million acres of land (UDEQ, 2005) and municipal and industrial water to more than 23 million people in seven states (Wyoming, Colorado, Utah, Arizona, New Mexico, Nevada, and California). The quality of water in this basin—especially the concentration of salinity—is, therefore, of great concern because of the potentially widespread adverse impact that poor water quality would have on water use throughout the Colorado River Basin.

Due to this concern, the Colorado River Basin states established the Colorado River Basin Salinity Control Forum (CRBSCF) in 1973 to organize interstate cooperation and provide the information needed to comply with Section 303(a) and (b) of the Clean Water Act. Sections 303(a) and (b) of the Clean Water Act set the requirements for development of water quality standards for interstate and intrastate waters by states and for submission of those standards to EPA for approval. In 1975 the Forum submitted to EPA the report *Water Quality Standards for Salinity Including Numeric Criteria and Plan of Implementation for Salinity Control-Colorado River System*. The numeric criteria and implementation plan contained in the report are reviewed and updated every 3 years to ensure continued compliance with the standards. The standards themselves require development of a plan to maintain the flow-weighted average annual salinity at or below 1972 levels while the basin states develop their compact-apportioned water supply.

The Forum selected stations below Hoover Dam, Parker Dam, and at Imperial Dam to measure salinity levels in the Colorado River. In general, over the last 30 years, the salinity concentrations have decreased at all three of the stations. Up to a million tons of salt load per year have been reduced because of this program, resulting in concentrations being lower at the numeric criteria stations by as much as 100 mg/L (CRSCF, 2005).

The salinity standard at Imperial Dam in Yuma, Arizona is currently 879 mg/L TDS. Salinity Control Programs must be implemented upstream of the dam in each basin state to meet this standard and improve municipal, industrial, and agricultural water quality.

To facilitate implementation of control projects, Title II of the 1974 Colorado River Basin Salinity Control Act authorized several salinity control units upstream of the Imperial Dam. Utah's portion of the Colorado River Basin is comprised of nine major sections including the Duchesne River watershed (CRSCF, 2005).

Utah has numeric water quality standards for TDS included in the Utah Administrative Code, Standards of Quality for Waters of the State (Title R317-2). Table 3-2 summarizes the standards pertaining to the 303(d) listed segments in the Duchesne River watershed.

Table 3-2. Water quality standards for impaired waters in the Duchesne River watershed

Designated Use	Description	TDS[1]
3A	Cold water aquatic life	—
3B	Warm water aquatic life	—
3C	Other aquatic life	—
4	Agricultural use	Irrigation: 1,200 mg/L (max) Stock watering: 2,000 mg/L (max)

[1]TDS limits may be adjusted if such adjustment does not impair the designated beneficial use of the receiving water. TDS standards shall be at background where it can be shown that natural or unalterable conditions prevent its attainment. In such cases, rulemaking will be undertaken to modify the standard accordingly.

The Duchesne River and its tributaries are located in part on the Uintah and Ouray Indian Reservation. Because there are no established water quality standards for waters on the reservation, Utah water quality standards were used as the basis for establishing water quality targets and evaluating water quality.

3.2 TMDL Target

Because there are no established water quality standards for waters within the boundaries of the Uintah and Ouray Indian Reservation, the Utah State water quality standards are used as the basis for establishing a TMDL target for the Duchesne River and Lake Fork River. (As discussed in Section 8, site-specific criteria for TDS are established for Indian Canyon Creek and Antelope Creek.) The Utah water quality standards include a numeric criterion for TDS, and the impairments for the Duchesne River and Lake Fork River are represented by exceedances of that criterion. Therefore, the numeric criterion of 1,200 mg/L is used as the water quality target for the TMDL analysis.

4. IMPAIRMENT ANALYSIS AND EVALUATION OF INSTREAM MONITORING DATA

Water quality data for the Duchesne River watershed were obtained from the UDEQ and downloaded from the USGS NWIS database. This section provides a description of available TDS data and analyses conducted to understand the current water quality conditions in the watershed. Because there is a significant amount of TDS data available throughout the watershed, the analyses focus only on those stations with observed violations of TDS water quality standards.

TDS data collected by UDEQ at 79 stations in the Duchesne River watershed were downloaded from EPA's STORET database. Over 232,000 records were available for the "dissolved solids" category in the database for the period 1975 to 2004. Water quality data from USGS ambient sampling and special studies in the Duchesne River watershed were also downloaded from the online NWIS database. Of the 16 USGS stations with TDS data in the Duchesne River watershed, only one station has data available within the last 10 years. Because of this, the data inventory and analysis for the Duchesne River watershed uses only the UDEQ TDS data. In addition, the Ute Tribe may have TDS data available for several sites throughout the watershed, and their data will be incorporated into the analysis, if available. Appendix D provides a table of all UDEQ and USGS stations with TDS data, including a summary of the datasets.

As water flows through a system, particles of soil, rock, and other materials accumulate in the water. The materials dissolve (or dissociate) in the water to form cations (positively charged ions) and anions (negatively charged ions). The term salinity refers to the total amount of dissolved cations and anions in water. Major ions in water are generally sodium, calcium, magnesium, potassium, chloride, sulfate, and bicarbonate. Metals (e.g., copper, lead, and zinc) and other trace elements (e.g., fluoride, boron, and arsenic) are usually only minor components of the total salinity. Salinity can be measured directly by filtering the sample to remove suspended solids and then evaporating a known quantity of water, leaving behind the salt. The salt residue is then weighed and the value obtained from this test is referred to as TDS, quantified in milligrams per liter (mg/L).

Pure distilled water has a TDS of 0 while TDS concentrations in rainfall and snowfall generally range from 0 to 10 mg/L. In comparison, the average TDS for the lower segment of the Duchesne River below the Uinta River confluence is 962 mg/L.

The salinity of a waterbody is important to many aquatic organisms because it regulates the flow of water into and out of an organism's cells (osmosis). Increases or decreases in salinity can cause a shift in the composition of the natural aquatic community. In the Duchesne River, it is likely that many native aquatic organisms have adapted to the natural salinity. The effects of salinity on nonnative species, however, are unknown. Saline waters can also adversely affect crop production depending on the amount of water applied, soil type and the salt tolerance of the crop. Livestock can also be adversely affected by saline water, lowering growth rates and milk production.

Natural sources, such as shale outcrops and saline soils, contribute to the salinity of a stream. Watersheds that have easily erodible soils or parent materials with high salt concentrations have streams and lakes that have naturally high salinity. However, there are also several potential anthropogenic sources of salinity, such as irrigation return flows, produced water from oil and gas drilling, disturbed land, road salting, and urban runoff.

The following sections contain analysis of the TDS data for stations in the Duchesne River watershed where exceedances of the TDS target were recorded. Analyses included an evaluation of impairments, monthly variations, and relationship between flow and TDS.

4.1 Summary of Stations with Violations

Of the 79 water quality stations with historical and current TDS data in the Duchesne River watershed, 12 reported exceedances of the State of Utah's water quality standard for TDS (Figure 4-1). These stations include 8 of the 10 stations on stream segments listed as impaired. Station 493601 on the impaired segment of Indian Canyon Creek and station 493580 on the impaired segment of Lake Fork River did not record any violations for TDS. Of the stations recording violations of the TDS standard, the two stations with the most data are those located on the Duchesne River near the town of Randlett (493410) and at the U.S. Highway 40 crossing at the town of Myton (493419).

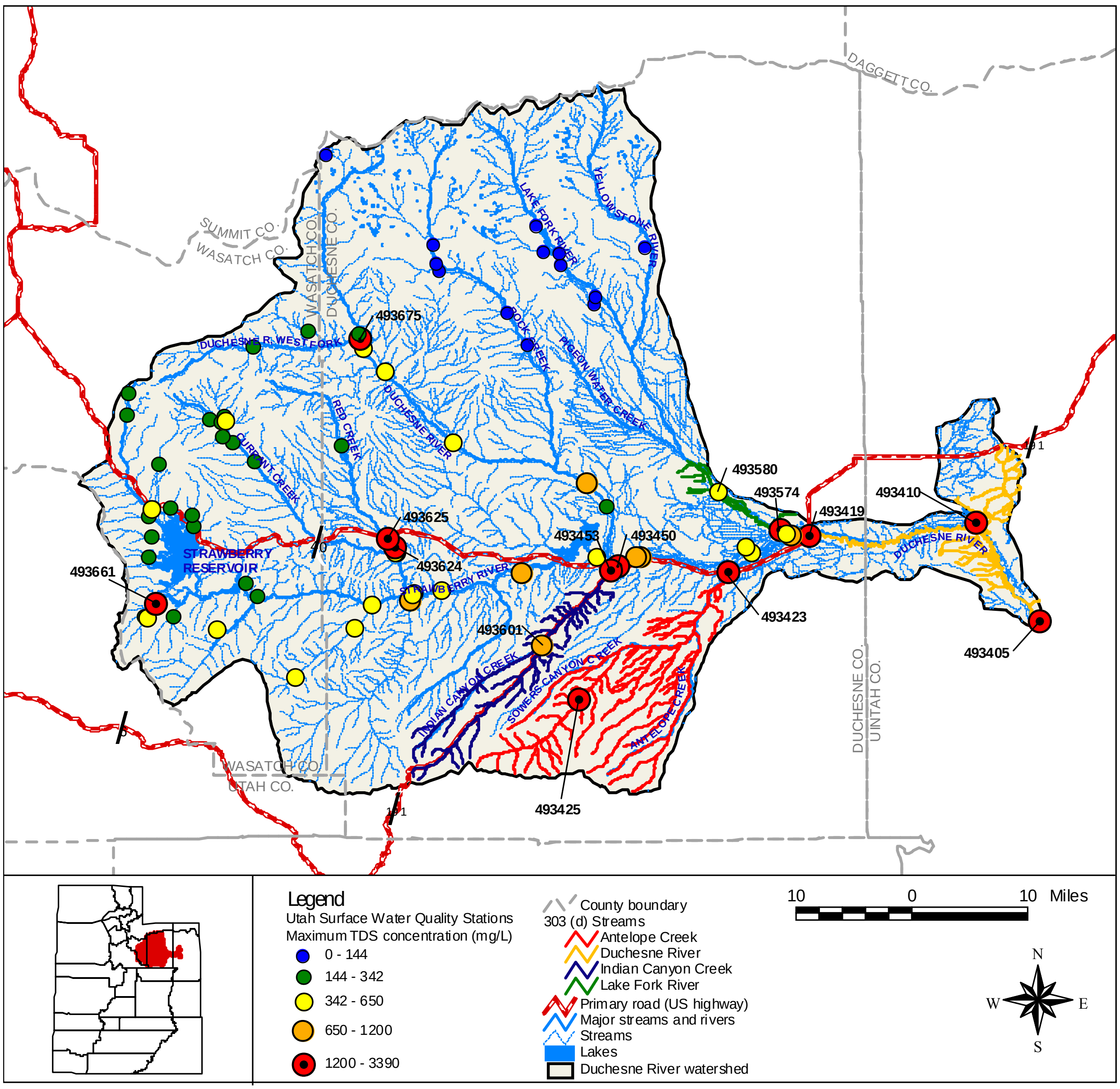

Figure 4-1. Locations of UDEQ water quality stations with data violating the TDS target

Summary statistics for water quality stations with TDS violations are presented in Tables 4-1 and 4-2. Only 3 of 12 stations had average TDS values greater than the 1,200 mg/L standard (493423, 493453, and 493624). Samples collected at these stations exceeded 1,200 mg/L more than 95 percent of the time. In addition, the percent violations at stations 493405 and 493425 showed an increase for recent samples when compared to the entire sampling period possibly due to the long-term drought the watershed has experienced since 1999.

TDS data for water quality stations that recorded TDS standard violations are shown graphically in Figures 4-2 through Figure 4-12. (Because there is only one data point available for station 493624, a figure of data from this station is not included.)

Table 4-1. Summary of TDS data for UDEQ water quality stations recording exceedances of the TDS target

Station ID	Station Description	No. of Samples	Avg (mg/L)	Min (mg/L)	Max (mg/L)	CV	First Sample	Last Sample
493405	Duchesne R above confluence with Green R	34	891.74	228	1,638	0.45	8/1/1979	5/9/2001
493410	Duchesne R near Randlett	230	962.33	184	2,316	0.49	8/17/1976	5/9/2001
493419	Duchesne R at Myton at U.S. 40 crossing	132	665.63	186	2,222	0.49	8/1/1979	6/7/2001
493423	Antelope Cr at U.S. 40 crossing	23	2,012.61	334	2,764	0.28	10/15/1980	5/28/1996
493425	Sowers Creek near USNF boundary	29	997.52	720	1,364	0.17	5/19/1987	6/7/2004
493450	Duchesne R above confluence with Strawberry R	83	337.55	104	1,800	0.57	8/1/1979	6/7/2001
493453	Indian Canyon Cr above confluence with Strawberry R	40	1,860.05	290	2,562	0.19	8/1/1979	5/24/2001
493574	Lake Fork R above confluence with Duchesne R	45	940.93	106	3,390	0.61	8/1/1979	6/7/2001
493624	Sand Wash above confluence with Red Cr	1	1,866.00	1866	1,866	-	3/11/1987	3/11/1987
493625	Red Cr above confluence with Current Cr	62	616.15	198	1,780	0.34	4/9/1986	6/5/2001
493661	Indian Cr above Westside Rd above Strawberry Res	44	332.34	234	1,858	0.71	6/29/1979	7/13/2004
493675	Duchesne R above Tabiona below confluence with WF Duchesne	78	231.10	94	2,052	0.94	11/3/1977	6/29/2004

Table 4-2. Summary of TDS violations for UDEQ water quality stations

Station ID	Total # of Samples	Total # of Violations	Percent Violating	Total # of Samples, 1998 to Present	Total # of Violations, 1998 to Present	Percent Violating, 1998 to Present
493405	34	10	29.41%	8	3	37.50%
493410	230	68	29.57%	25	3	12.00%
493419	132	7	5.30%	10	0	0.00%
493423	23	22	95.65%	0	0	0.00%
493425	29	5	17.24%	20	5	25.00%
493450	83	1	1.20%	11	0	0.00%
493453	40	38	95.00%	7	6	85.71%
493574	45	9	20.00%	10	2	20.00%
493624	1	1	100.00%	0	0	0.00%
493625	62	1	1.61%	10	0	0.00%
493661	44	1	2.27%	40	1	2.50%
493675	78	1	1.28%	25	0	0.00%

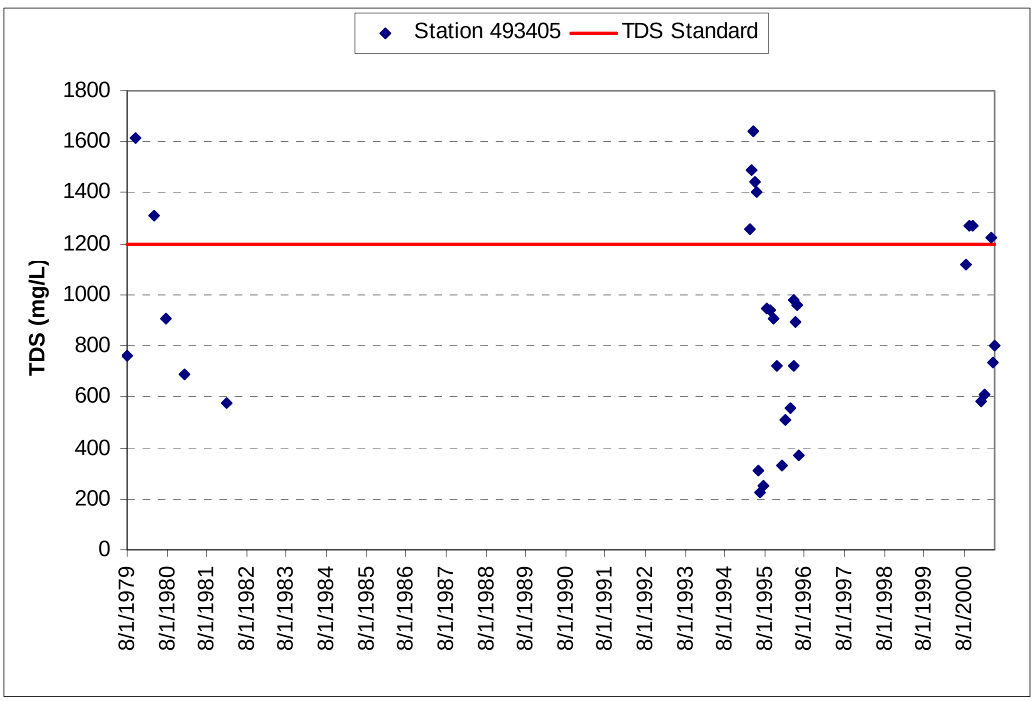

Figure 4-2. All TDS observations for station 493405 – Duchesne River above Green River confluence

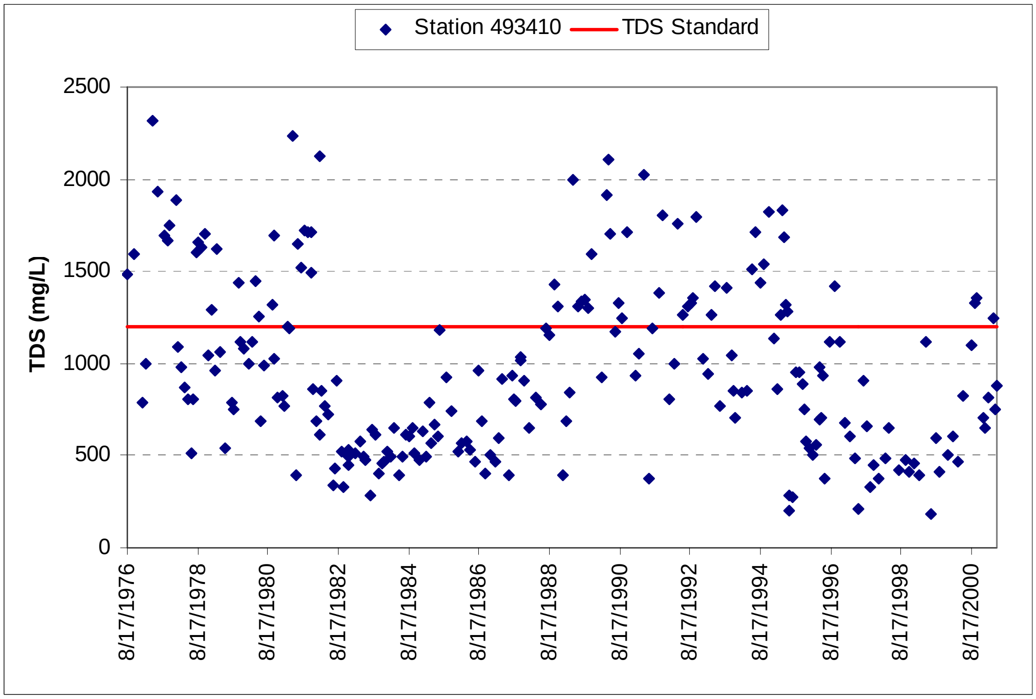

Figure 4-3. All TDS observations for station 493410 – Duchesne River near Randlett

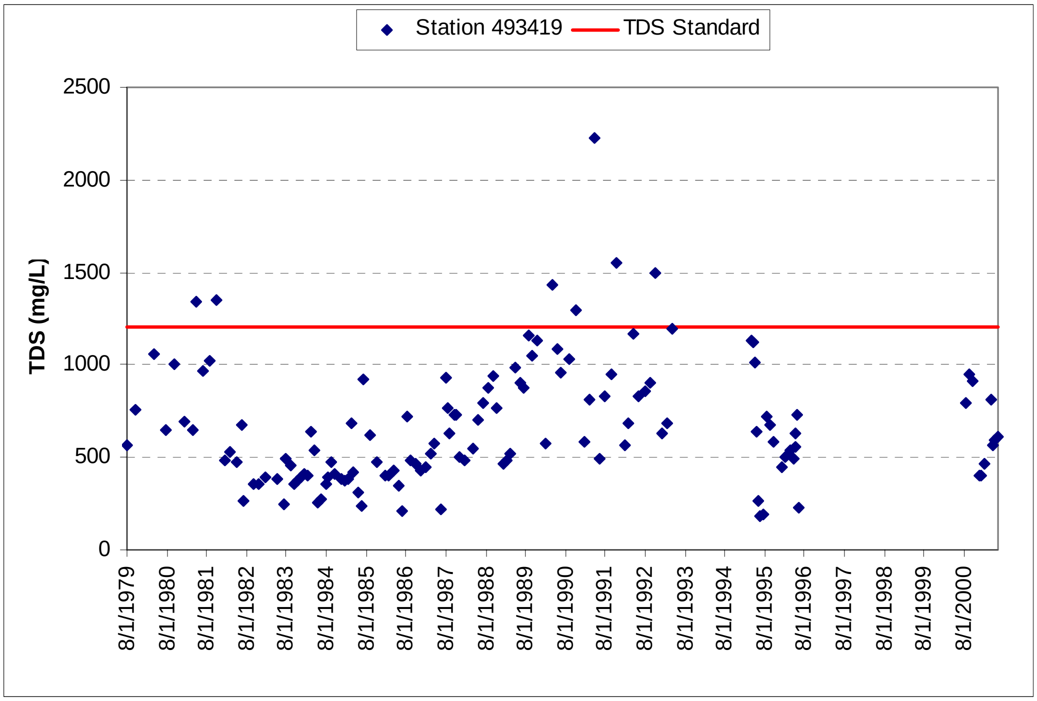

Figure 4-4. All TDS observations for station 493419 – Duchesne River at Myton at U.S. Highway 40 crossing

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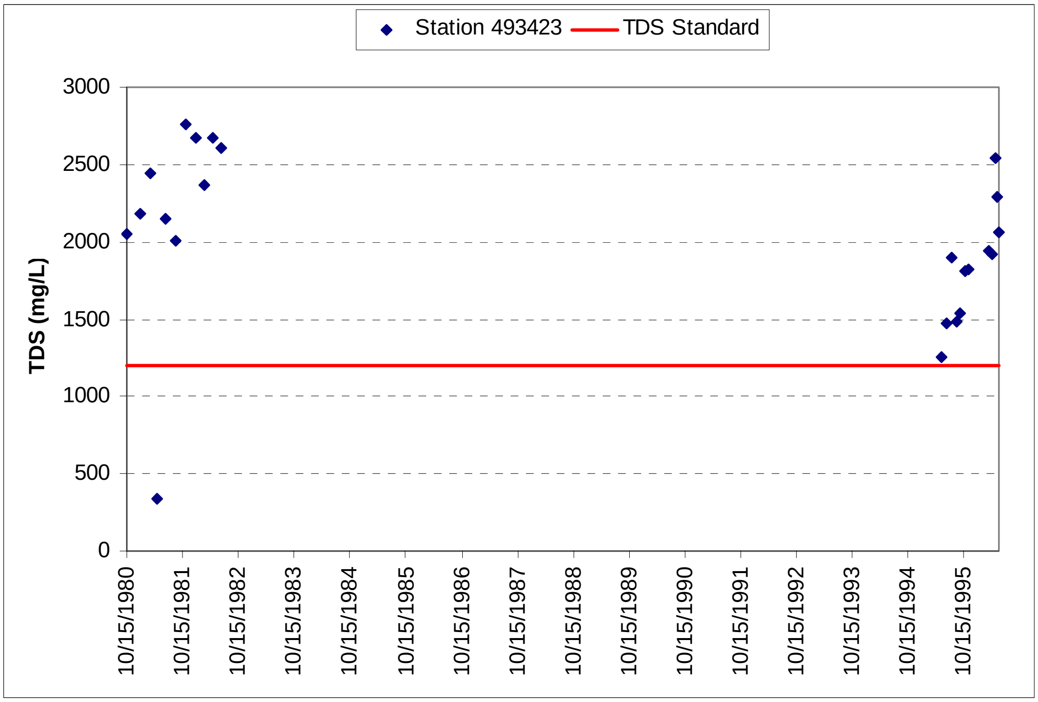

Figure 4-5. All TDS observations for station 493423 – Antelope Creek at U.S. Highway 40 crossing

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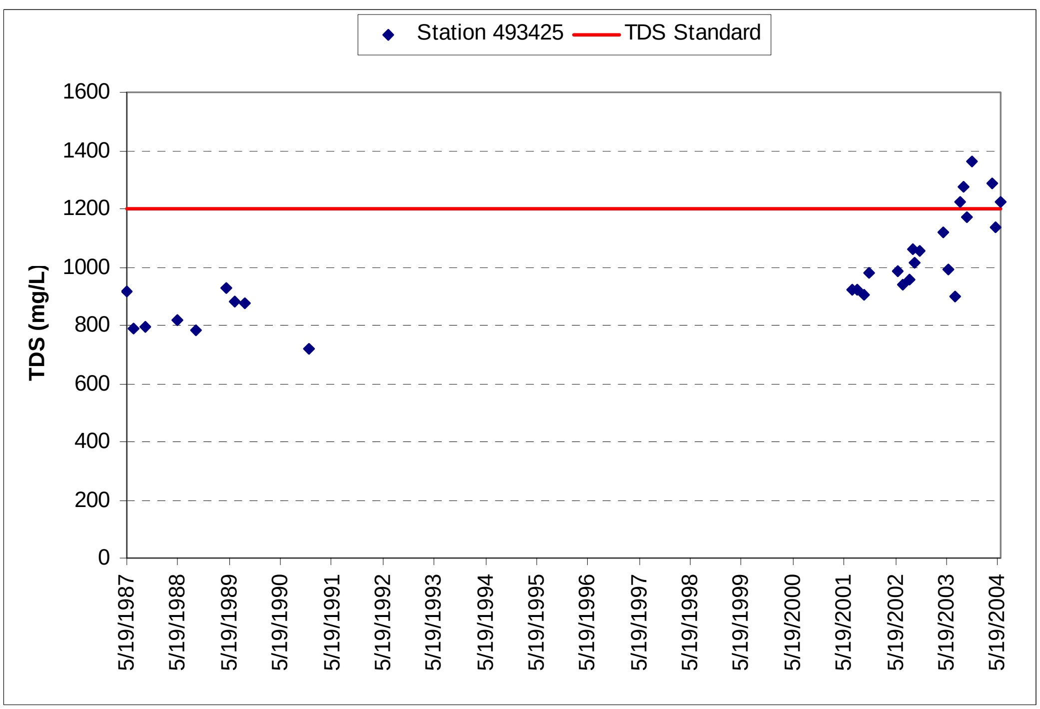

Figure 4-6. All TDS observations for station 493425 – Sowers Creek near USNF boundary near USGS gauge 09288900

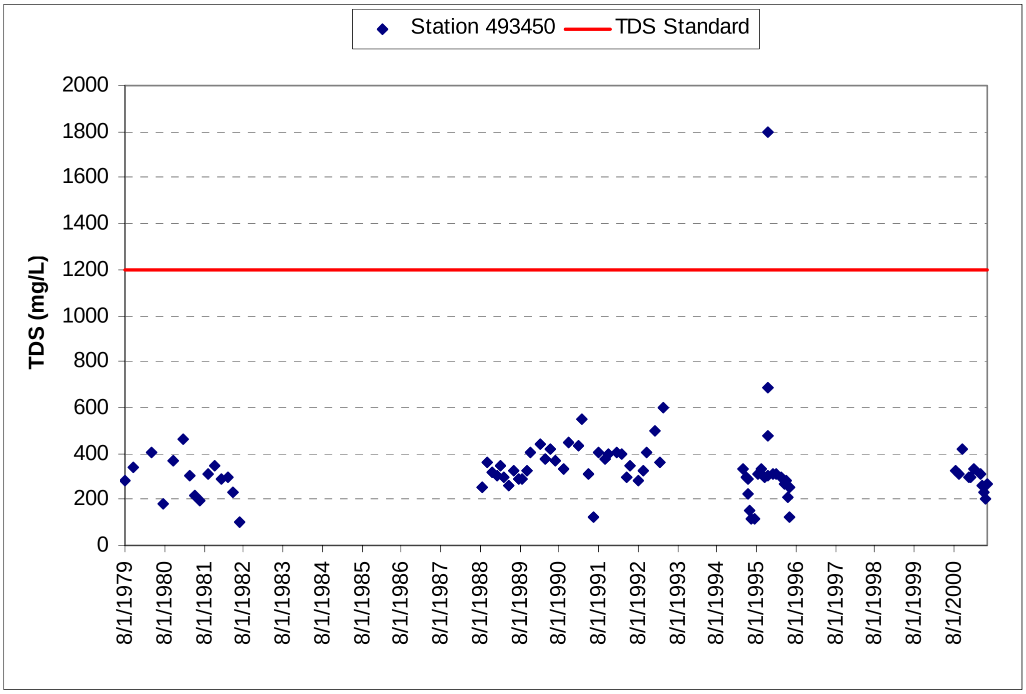

Figure 4-7. All TDS observations for station 493450 – Duchesne River above Strawberry River confluence

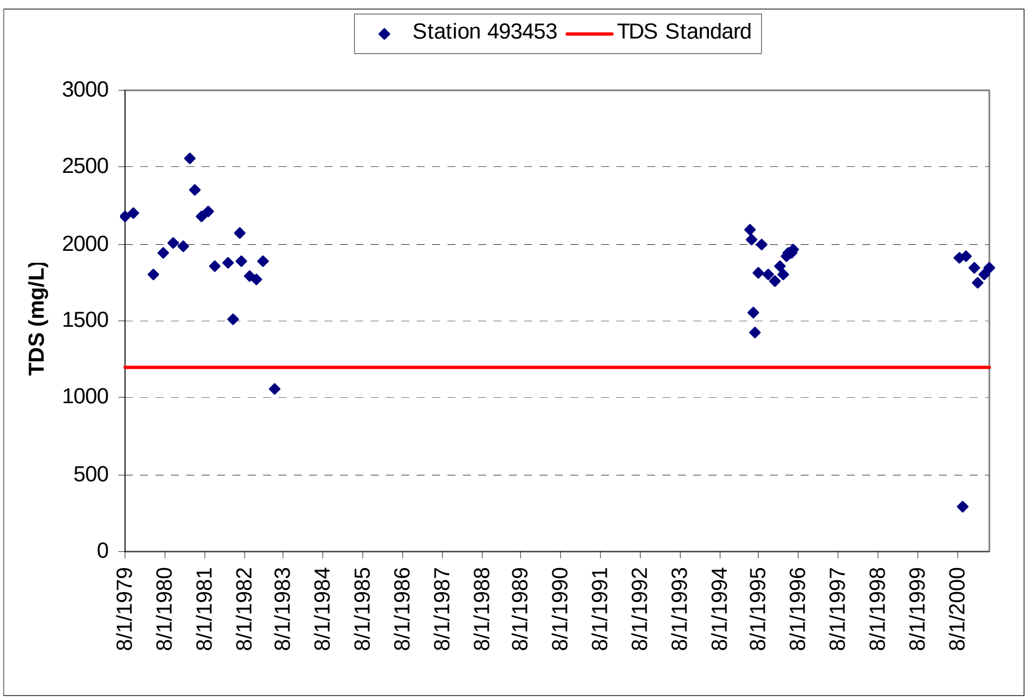

Figure 4-8. All TDS observations for station 493453 – Indian Canyon Creek above Strawberry River confluence

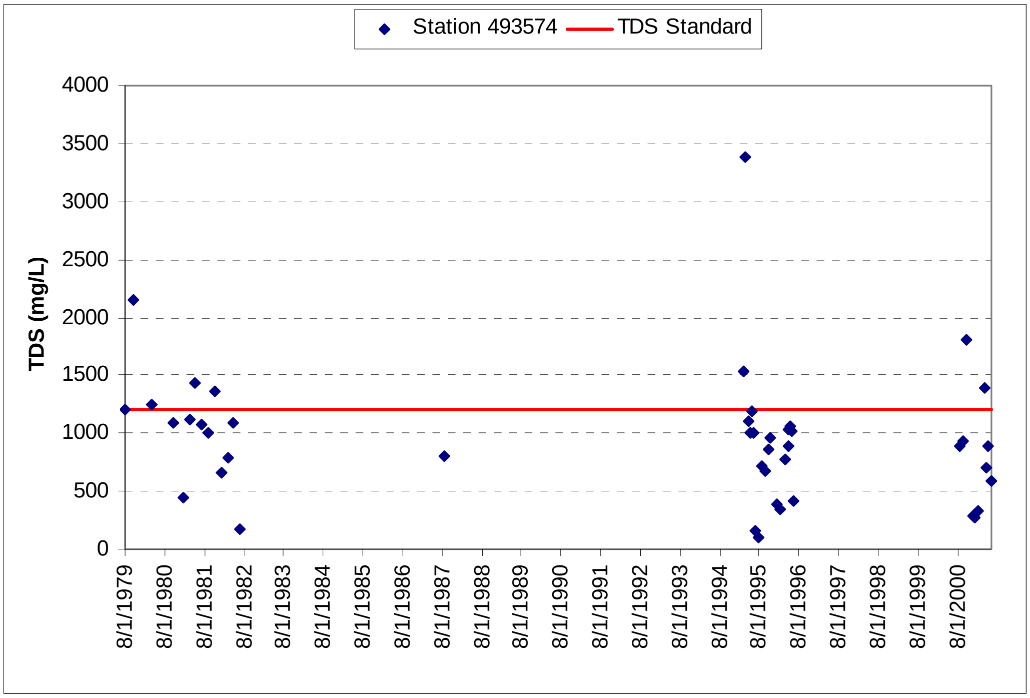

Figure 4-9. All TDS observations for station 493574 – Lake Fork River above confluence with Duchesne River

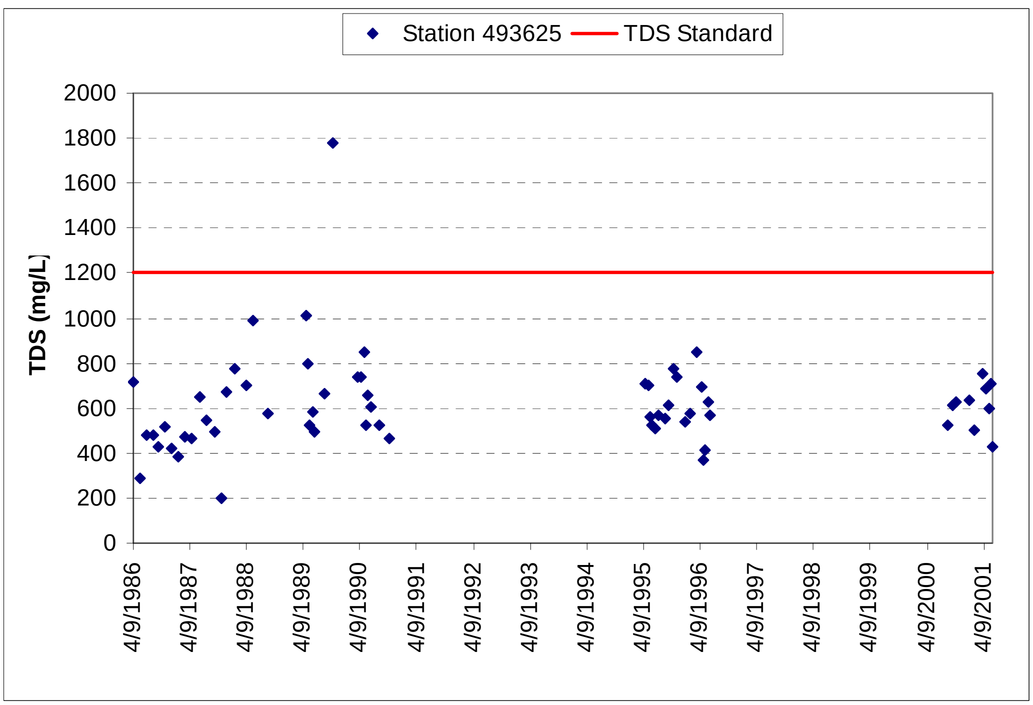

Figure 4-10. All TDS observations for station 493625 – Red Creek above Current Creek confluence

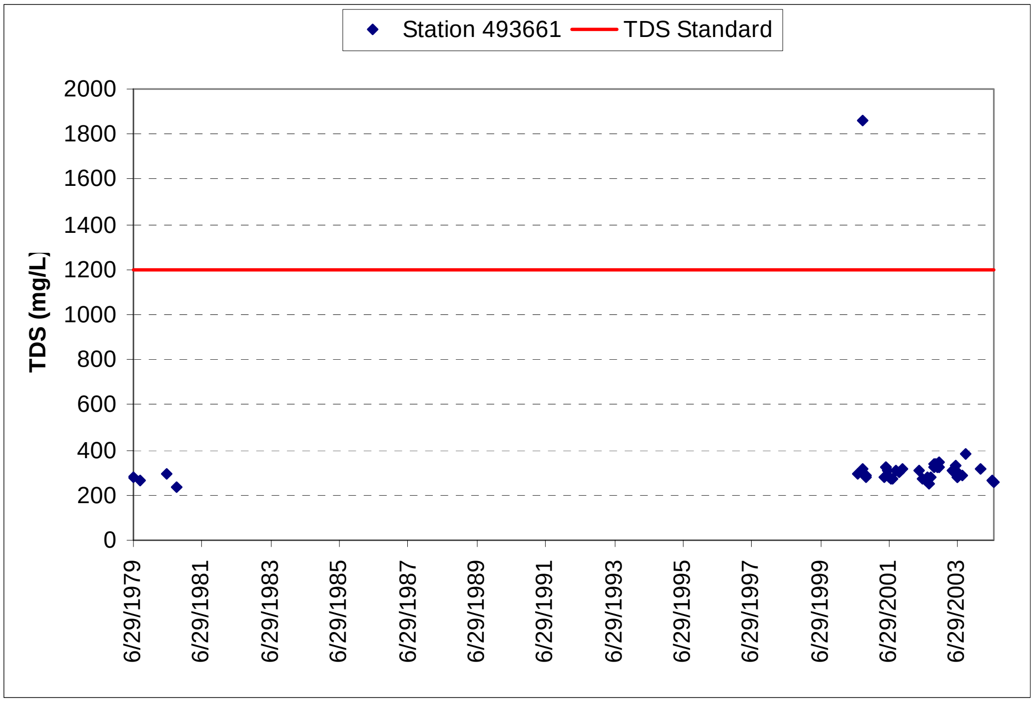

Figure 4-11. All TDS observations for station 493661 – Indian Canyon Creek above Westside Rd. above Strawberry Reservoir

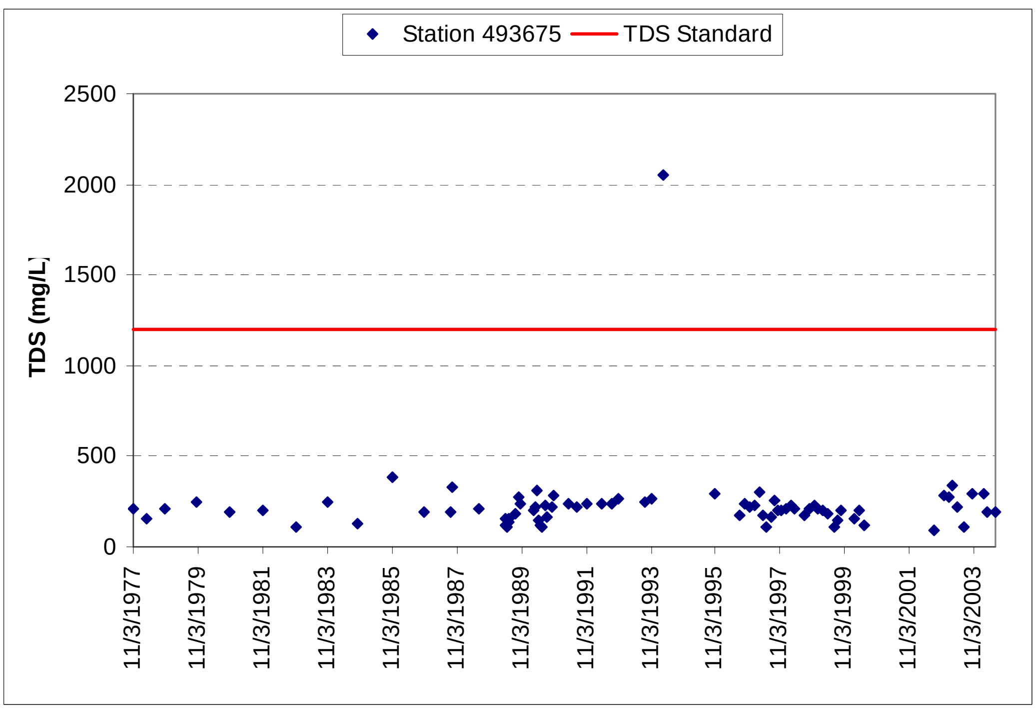

Figure 4-12. All TDS observations for station 493675 – Duchesne River above Tabiona below West Fork Duchesne River confluence

4.2 Temporal Variation in TDS and Flow

This section presents a summary of the monthly variations in flow and TDS data from coinciding USGS gauges and UDEQ water quality stations, as presented in Figure 4-13. Figures 4-14 through 4-22 present the monthly average TDS concentrations and monthly average flow values at stations violating TDS standards and located at or in close proximity to a USGS gauge[1]. Average flow patterns are similar at all gauges with flows remaining consistent throughout the fall, winter, and early spring and a peak during May or June, likely a result of the spring snowmelt. Stations experiencing higher flows tend to experience more variable monthly TDS averages. Those stations with lower flows have monthly TDS averages that remain fairly consistent (e.g., within a 100 mg/L range for most months). Stations with larger flows experience lower TDS from May through July (during higher flows) and have increased TDS during fall and spring. At those stations, winter TDS averages seem to be within the range of summer averages, while flows are only slightly higher than those of spring and fall.

[1] The USGS gauge at Randlett (9302000) was moved in 2004 due to difficulties in maintaining a rated cross section, icing, and channel configuration (USFWS, 2005). The change in physical conditions surrounding the gauge might have affected flow measurements.

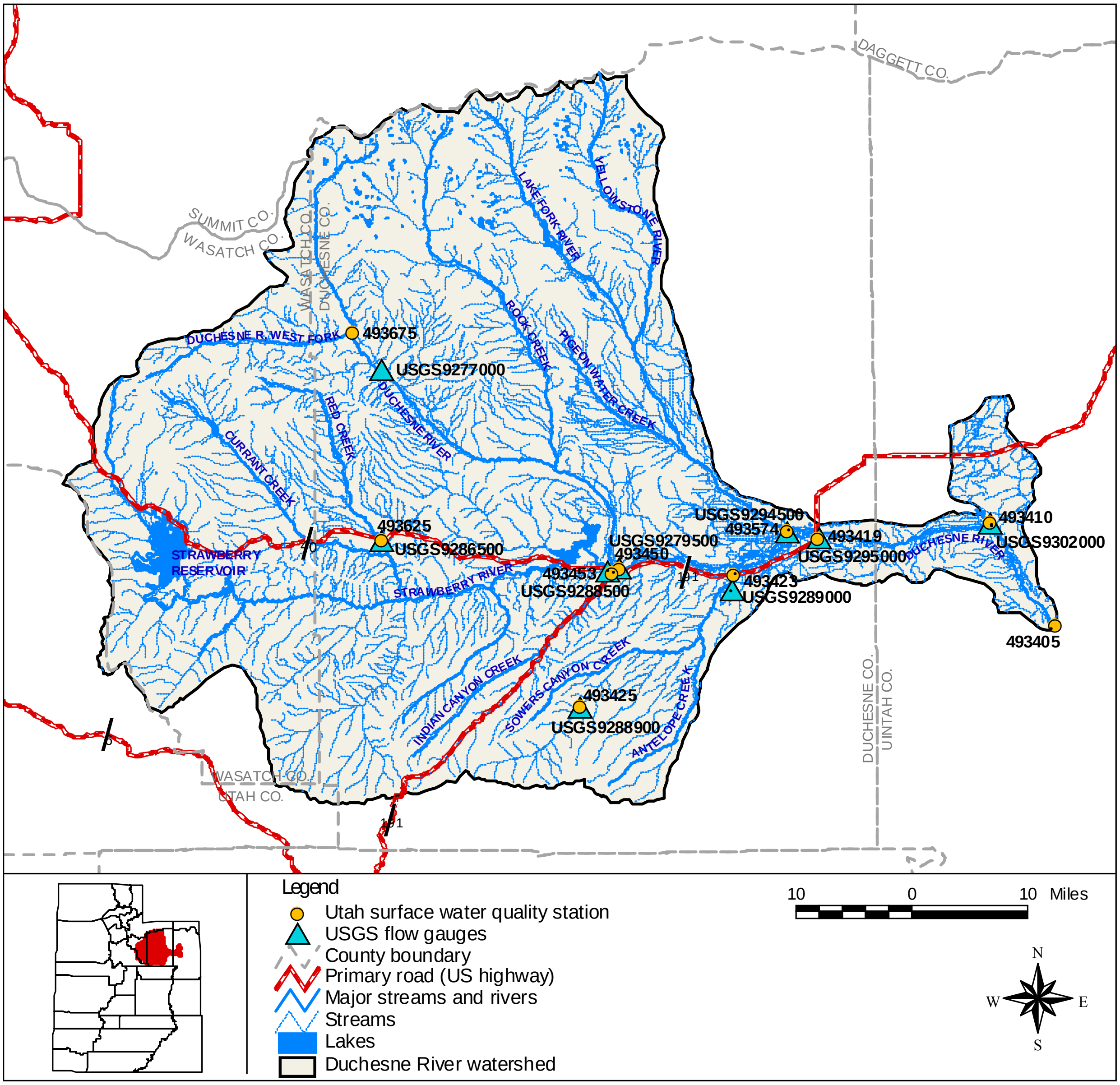

Figure 4-13. UDEQ stations and USGS gauges in proximity

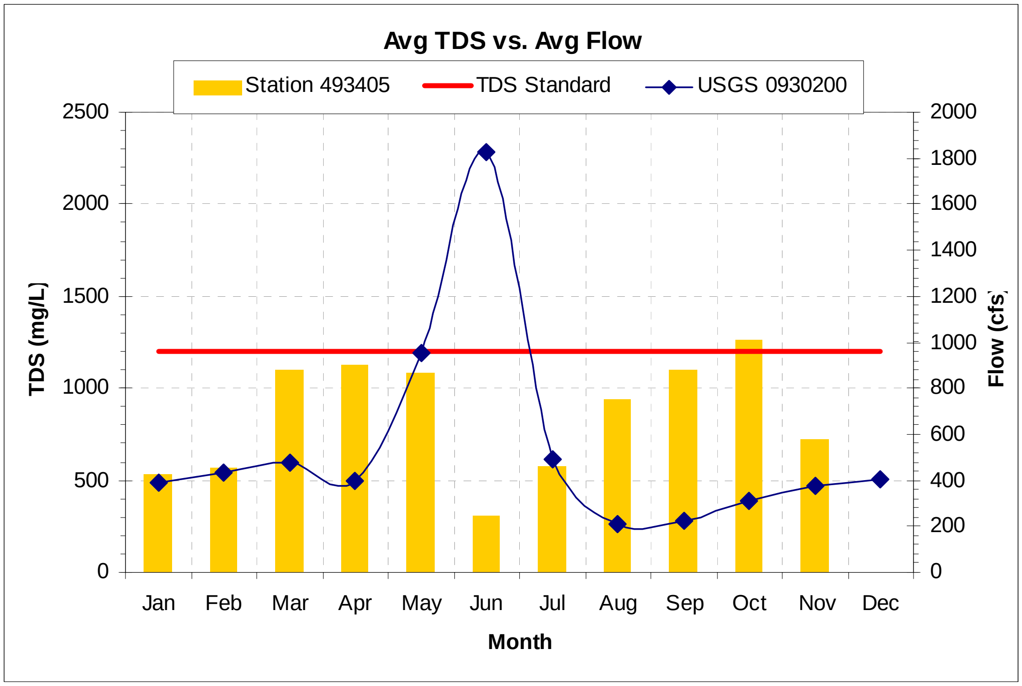

Figure 4-14. Average monthly TDS and flow for station 493405 and flow gauge 09302000 (Duchesne River above confluence with Green River)

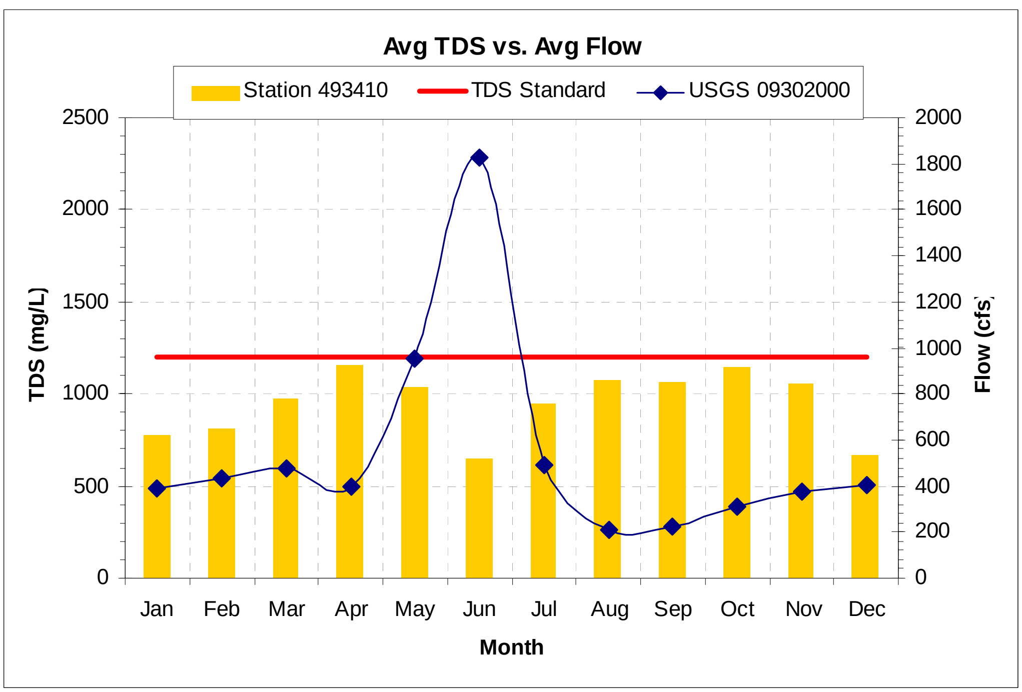

Figure 4-15. Average monthly TDS and flow for station 493410 and flow gauge 09302000 (Duchesne River at Randlett)

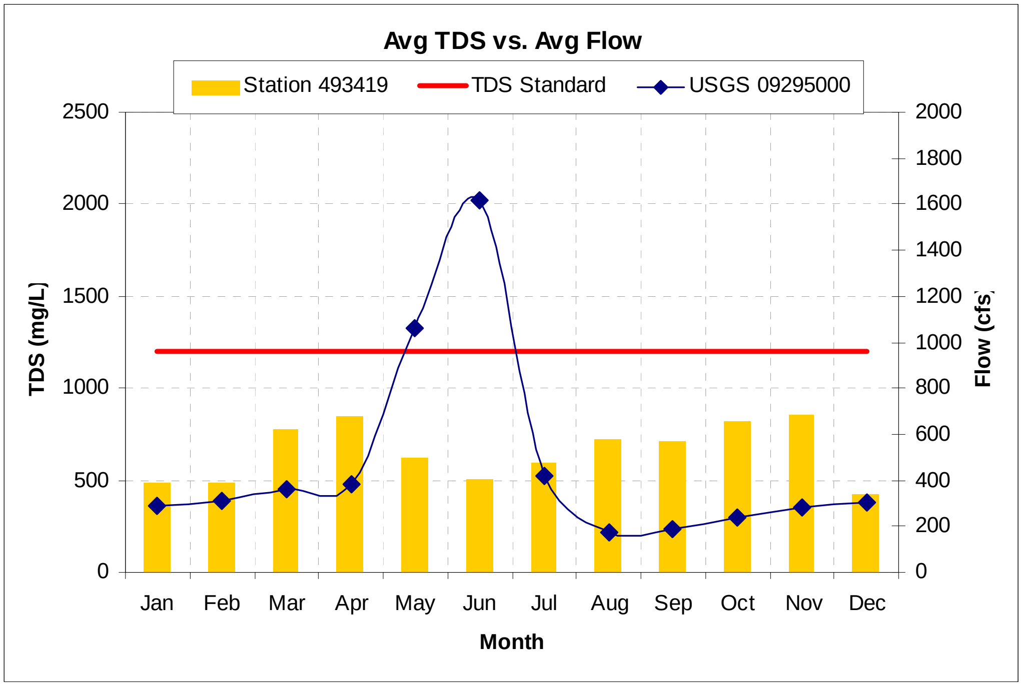

Figure 4-16. Average monthly TDS and flow for station 493419 and flow gauge 09295000 (Duchesne River at Myton)

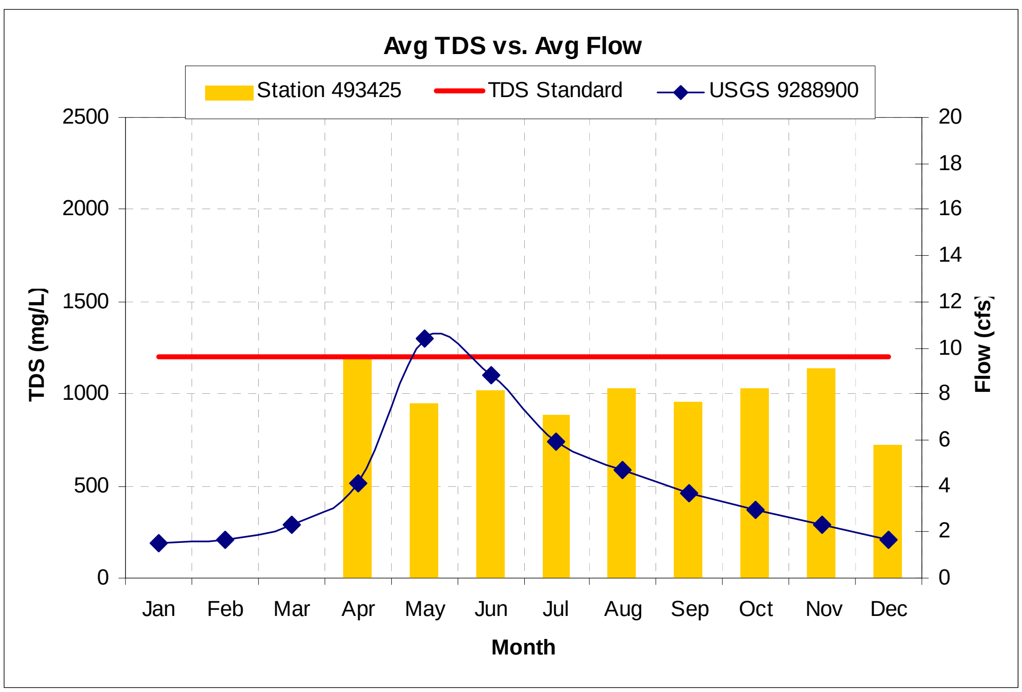

Figure 4-17. Average monthly TDS and flow for station 493425 and flow gauge 09288900 (Antelope Creek)

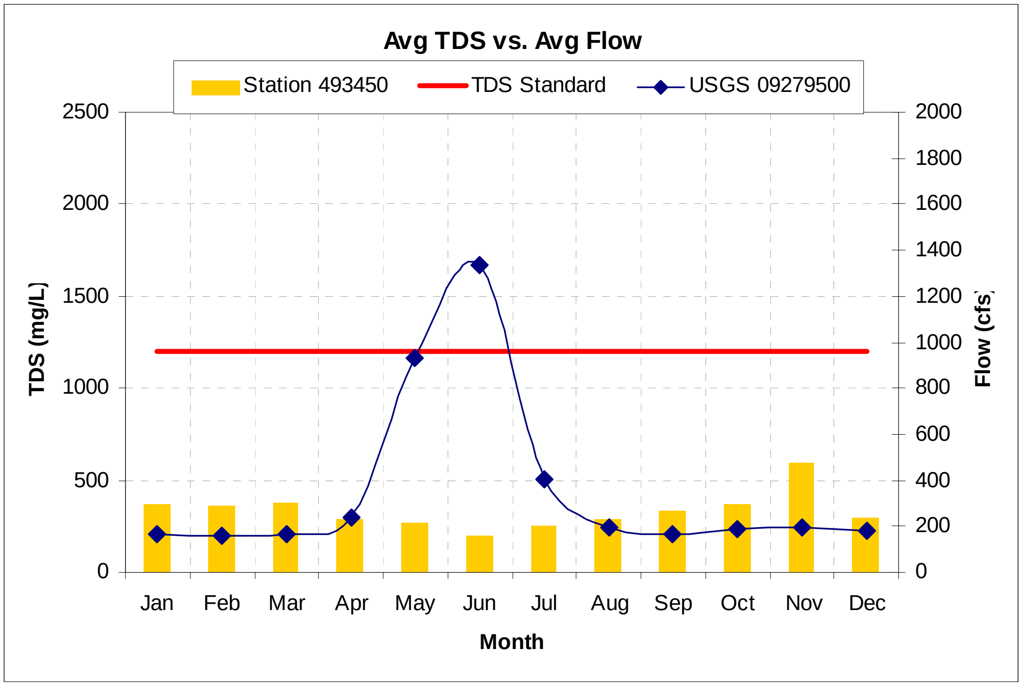

Figure 4-18. Average monthly TDS and flow for station 493450 and flow gauge 09279500 (Duchesne River below Strawberry River)

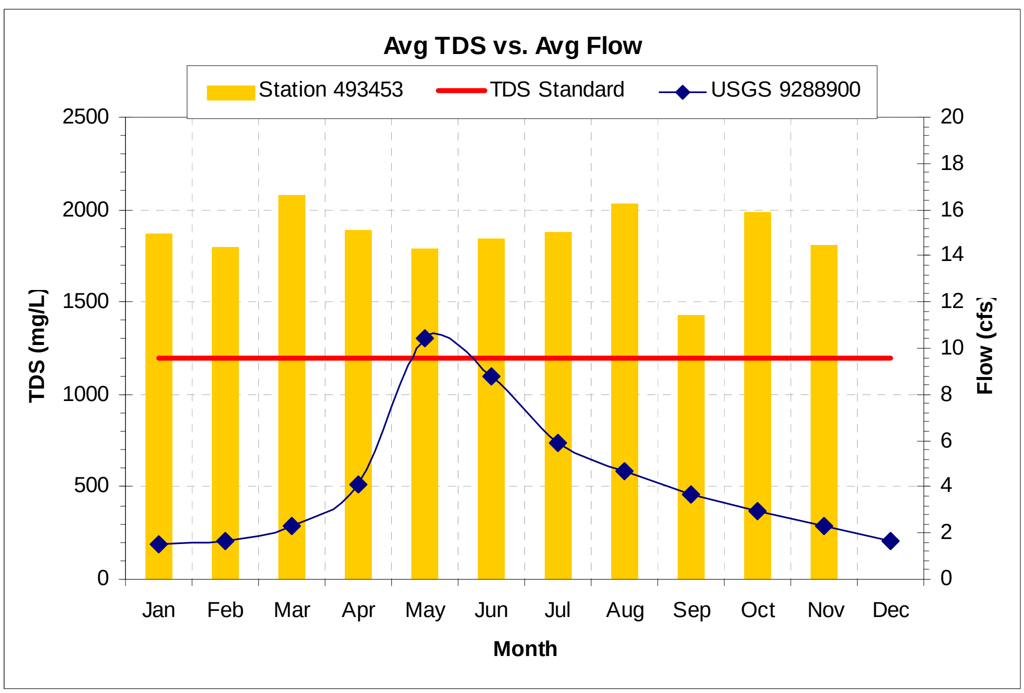

Figure 4-19. Average monthly TDS and flow for station 493453 (Indian Canyon Creek) and flow gauge 09288900 (Antelope Creek Flows)

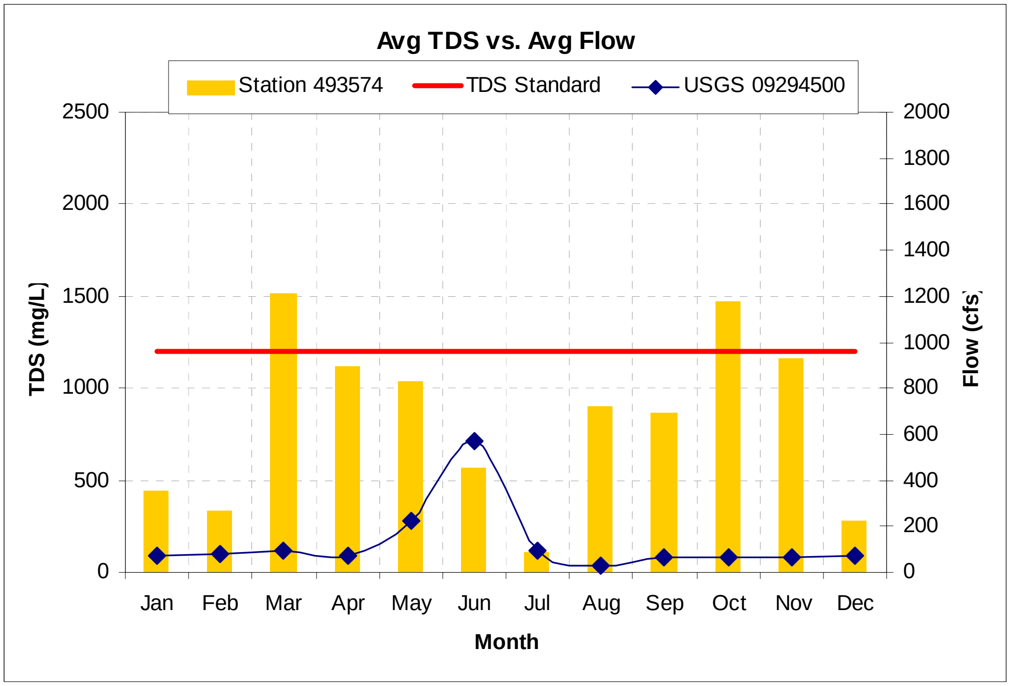

Figure 4-20. Average monthly TDS and flow for station 493574 and flow gauge 09294500 (Lake Fork River)

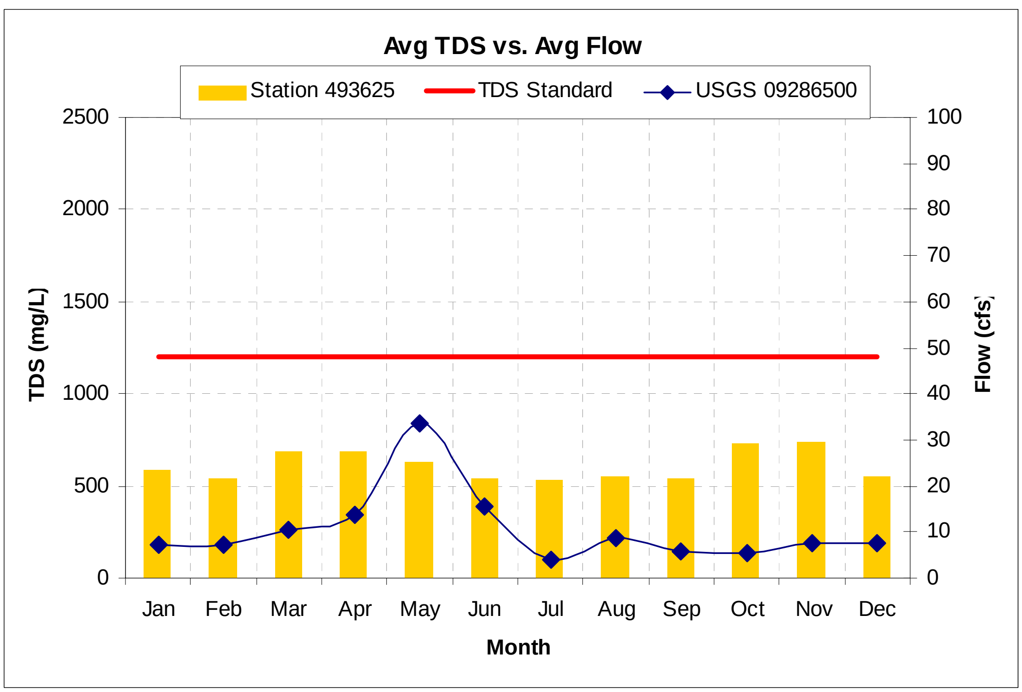

Figure 4-21. Average monthly TDS and flow for station 493625 and flow gauge 09286500 (Red Creek)

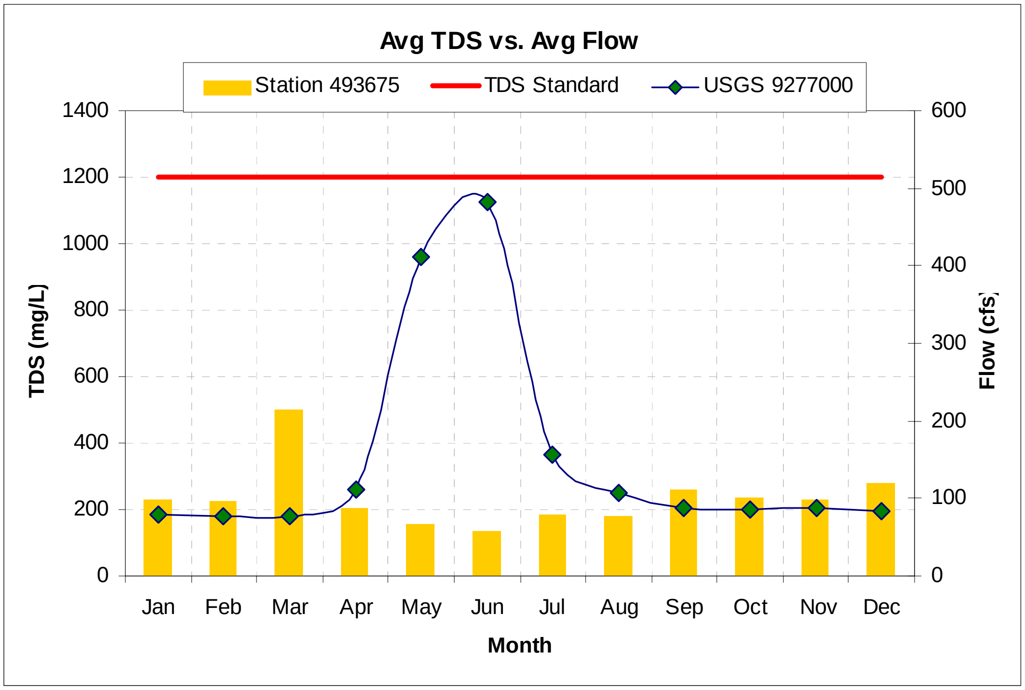

Figure 4-22. Average monthly TDS and flow for station 493675 and flow gauge 9277000 (Duchesne River below West Fork of the Duchesne River)

4.3 TDS Versus Flow

To investigate any relationships between TDS and flow, matching data were isolated for UDEQ stations and USGS gauges co-located throughout the watershed. Figures 4-23 through 4-26 display corresponding observations of TDS and daily flow at four locations[2]. Correlation coefficients indicate that the relationship between flow and TDS is not very strong, but the figures show that TDS tends to decrease when flows increase, with the highest TDS concentrations typically occurring during low flows.

[2] The USGS gauge at Randlett (9302000) was moved in 2004 due to difficulties in maintaining a rated cross section, icing, and channel configuration (USFWS, 2005). The change in physical conditions surrounding the gauge might have affected flow measurements.

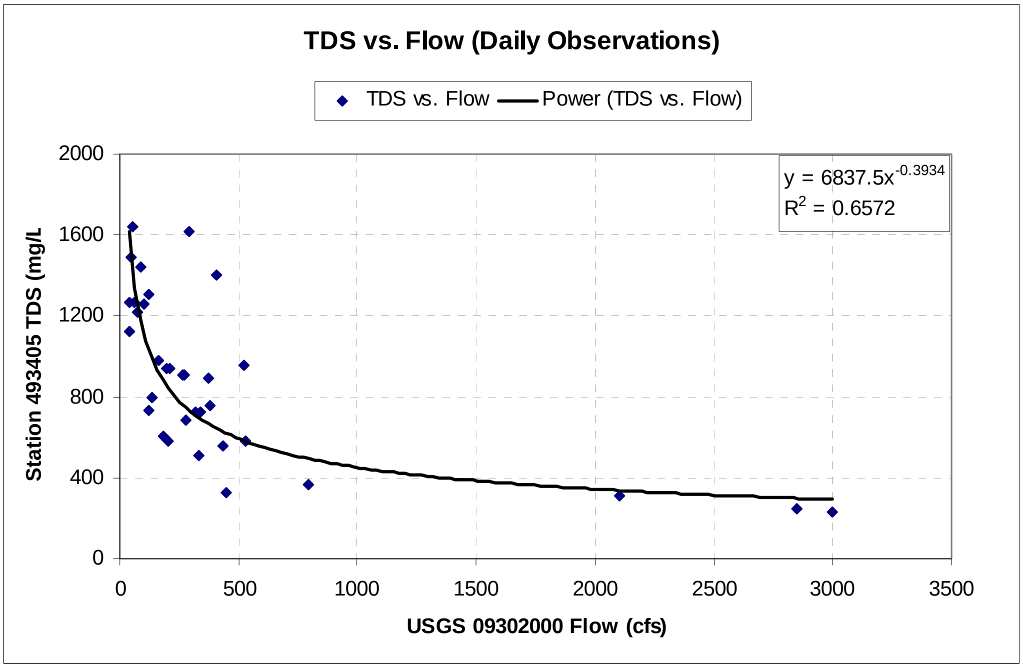

Figure 4-23. Daily TDS vs. daily flow for station 493405 and flow gauge 09302000 (Duchesne River above confluence with Green River)

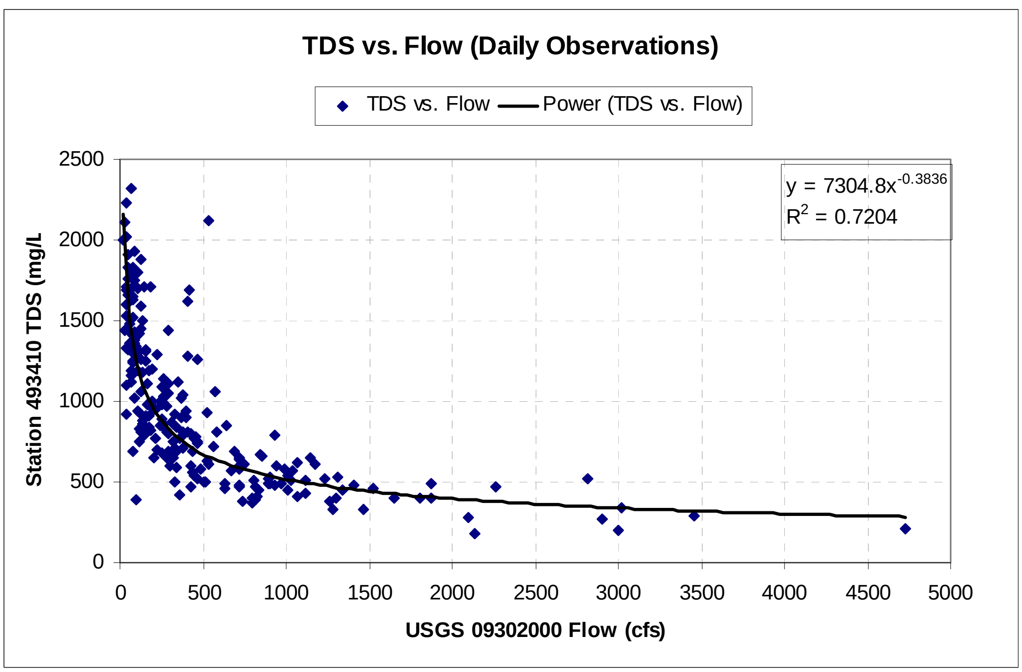

Figure 4-24. Daily TDS vs. daily flow for station 493410 and flow gauge 09302000 (Duchesne River at Randlett)

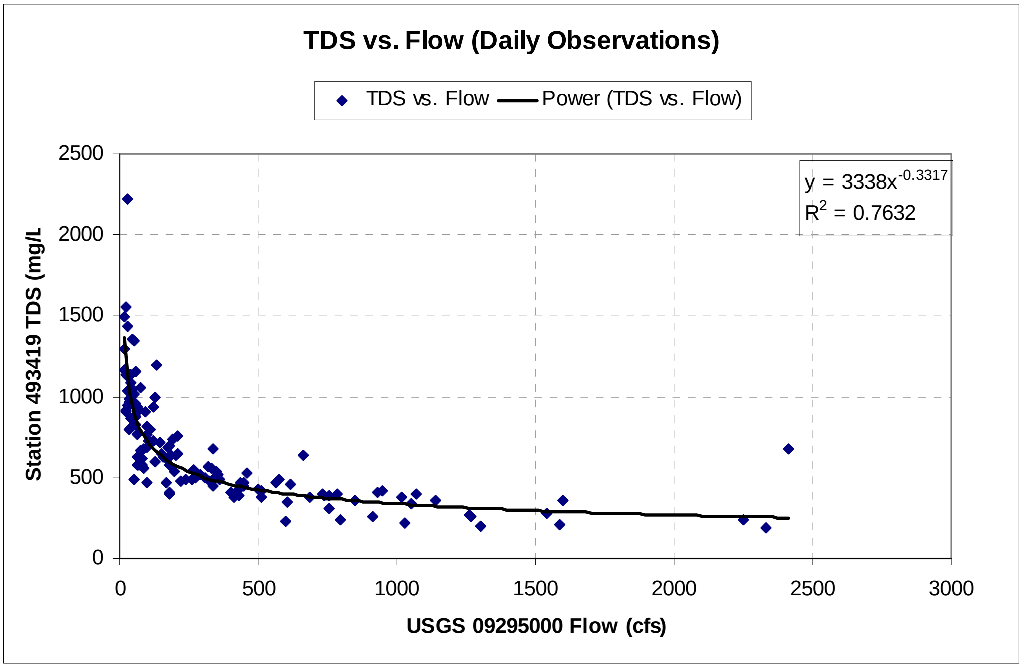

Figure 4-25. Daily TDS vs. daily flow for station 493419 and flow gauge 09295000 (Duchesne River at Myton)

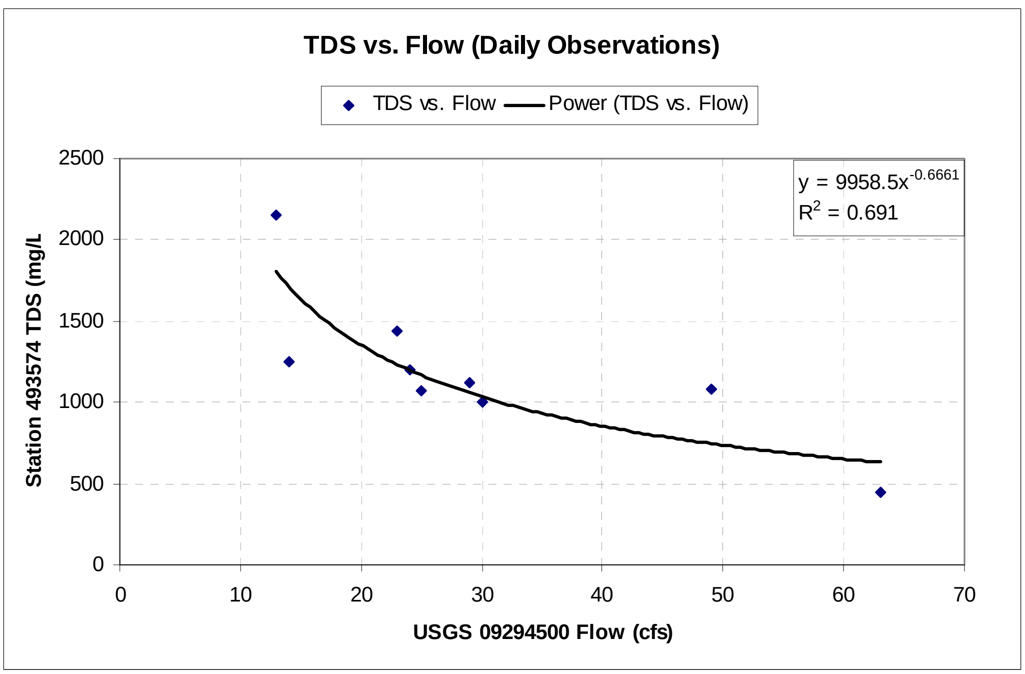

Figure 4-26. Daily TDS vs. daily flow for station 493574 and flow gauge 09294500 (Lake Fork River)

4.4 Conclusions

Of the 79 water quality stations with historical and current water quality data in the Duchesne River watershed, 12 reported exceedances of Utah's TDS water quality standards. Only 3 of the 12 stations had average TDS values greater than the 1,200 mg/L standard. Samples collected at these stations exceeded 1,200 mg/L more than 95 percent of the time. In addition, for two of the stations, there was a percentage increase for recent samples when compared to the entire sampling period. For stations with data for the early 1990s, there seems to be a consistent peak in TDS concentrations in mid-1990.

Stations experiencing higher flows tend to experience more variable monthly TDS averages. Stations with lower flows have monthly TDS averages that remain fairly consistent (e.g., within a 100 mg/L range for most months). Stations with larger flows experience lower TDS from May through July (during spring runoff) and have increased TDS during fall and spring. At those stations, winter TDS averages seem to be within the range of summer averages, while flows are only slightly higher than those of spring and fall.

Corresponding observations of TDS and daily flow indicate that, generally, TDS tends to decrease when flows increase, with the highest TDS concentrations typically occurring during low flow.

5. SOURCE ASSESSMENT

This section summarizes potential and expected sources of TDS impairment in the Duchesne River watershed.

5.1 Nonpoint Sources

Significant natural and anthropogenic sources of TDS exist in the Duchesne River watershed. The area is naturally saline, and there are background contributions of TDS resulting in elevated concentrations in watershed streams. Geologic features of the watershed are dominated by the slightly to moderately saline Uinta and Duchesne River formations and the highly saline Mancos Shale formation. However, due to the highly modified hydrology of the watershed from canals and diversions, it is practically impossible to identify the true “natural” condition of the watershed.

Surface and subsurface irrigation return flows that dissolve and transport TDS to receiving streams have been identified as a significant source of TDS in the watershed. Irrigation water and natural precipitation that is not taken up by vegetation, evaporated into the atmosphere, or held in the soil, percolates through the soil and enters the shallow alluvial aquifer (i.e. groundwater), eventually returning to watershed streams as baseflow. High deposition of salts on the ground surface essentially seals the soil, preventing percolation of precipitation. This action greatly enhances the effects of runoff, increasing the velocity of runoff, developing sheet flows, and increasing TDS loading.

Irrigation return flows in the watershed are a potential source of salinity because they dissolve and transport salts from fields and return them to surface waters through surface and subsurface flows. Flood irrigation is a potentially major source of salinity because of the large amounts of water used with the method and the need to leach salts from agricultural fields. During the field assessment, it was noted that almost all of the pasture, crop and hay fields in the Duchesne River watershed were irrigated by some method. Some fields were irrigated with flood irrigation through the use of canals. Seepage of water from unlined canals is a known contributor to TDS loading of streams in the Duchesne River watershed. BOR and NRCS (1993) estimates that canal seepage increases the TDS load by 67.17 tons per mile of canal. Return flows are mostly through subsurface flows, and several of these returns were observed to be entering active stream channels. Other types of irrigation in the watershed include more efficient center pivot, wheel line, and hand line sprinkler systems.

Subsurface bedrock formations, particularly Mancos Shale, dissolve easily and contribute TDS to the groundwater passing through them. Water quality is degraded by irrigation return flows high in salinity entering the creeks and rivers. As water flows through the watershed and is used and reused for irrigation and other purposes, it accumulates increasing amounts of salt. Salt can also accumulate on the land surface in areas of saline soils or areas of poor drainage where groundwater rises to the surface and evaporates, leaving the soluble salts on the surface. When salts accumulate on the surface, they are available for transport to watershed streams.

Livestock grazing can result in surface disturbance and soil compaction, which can decrease infiltration, vegetative cover, and streambank stability, thereby potentially increasing TDS loading. Dahkuh and Gifford (1980) found that untrampled soils exhibit more than two times the infiltration rate as trampled soils. They also reported that by increasing the cover of grasses from 30 percent to 50 percent, erosion was decreased by more than 50 percent. Streambank erosion caused by watering animals in readily accessible streamside areas can also result in increased sediment production, and accompanying TDS loadings (Dahkuh and Gifford, 1980).

Salt tolerant plants (particularly greasewood and Tamarix, also known as salt cedar) are well established throughout the lower Duchesne River watershed and were noted in the riparian corridors. Greasewood is a native plant to Utah and has deep rooted vegetation. Tamarix develops deeper roots than most native vegetation and is able to survive better than most native vegetation in riparian corridors with lower groundwater tables and extended drought conditions. In addition, Tamarix is able to germinate and seed when many native plants cannot. Tamarix is considered both a direct and indirect source of increased TDS to surface waters. First, Tamarix excretes salt as it grows, and these salts are deposited within the riparian corridor and are available to be absorbed back into the water column. Secondly, Tamarix trees are an indirect source of impairment because of the relatively large quantities of water they consume. This can lead to reduced flows and higher salinity concentrations in areas where the riparian corridor is densely populated with Tamarix.

5.2 Point Sources

Data retrieved from EPA's Permit Compliance System showed one permitted facility with a TDS discharge in the Duchesne River watershed (Figure 5-1). According to the Statement of Basis (2002) for the Duchesne City Wastewater Treatment Facility (UPDES Permit #UT0020095), it is a minor municipal discharger that consists of four discharging lagoons. The facility serves the City of Duchesne with a current population of 1,700 people. The facility is approximately one mile east of Duchesne and discharges very intermittently to the Duchesne River. The facility has operated as a total containment lagoon since October 1988. All discharge monitoring reports submitted by the permittee to the state indicate no discharges, and the state has indicated very intermittent discharges from this facility. In 2004, there was only one discharge, and, in 2005, the facility discharged in March and September. According to the 2002 Statement of Basis, the state's monitoring data are minimal from this facility, and results show compliance with the permit limits, although one exceedance was recorded by the state in 2004. Overall, the analysis of point source data revealed the current impact of point source TDS contributions to the Duchesne River is insignificant.

5.3 Watershed Field Survey

The purpose of a watershed field survey is to provide a general characterization of the types, locations, and severity of pollution sources contributing to water quality impairment in the 303(d)-listed segments of the Duchesne River watershed. The array of pollutant sources affecting streams in this watershed are most likely a result of historic and current land use practices as well as natural processes.

A visual, screening level assessment of TDS sources was conducted throughout the watershed during May/June and September 2005. This assessment included photo documentation, global positioning system (GPS) locational indexing (in September), and narrative descriptions of current and potential sources of water quality impairment in 303(d) listed segments. Each of the listed segments was surveyed from available access points and road networks, and relevant features were documented. Obvious water quality impairments associated with the identified sources were noted (e.g., streambank erosion and destabilization, dewatered stream channels, natural sources). The field source assessment was conducted in coordination with the UDEQ Division of Water Quality and the Ute Tribe. Figure 5-2 highlights the segments that were assessed during the May/June survey and the locations of water quality sampling during the September survey. The results of the five water quality samples taken in the Duchesne River in September were not available when this document was written. (The sampling site at Myton is not included in Figure 5-2 because no latitude and longitude coordinates were available.)

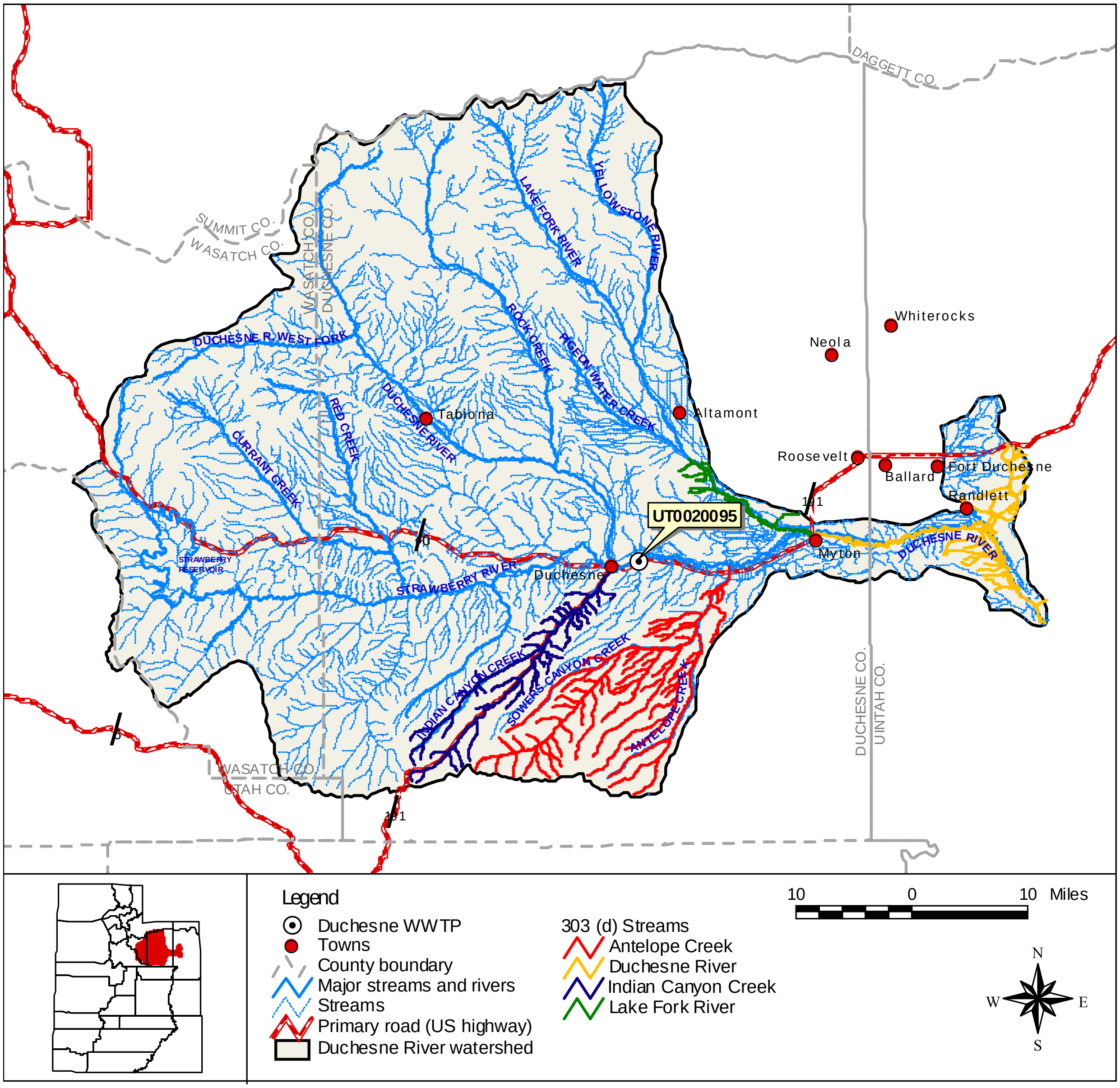

Figure 5-1. Permitted point source discharges in the Duchesne River watershed

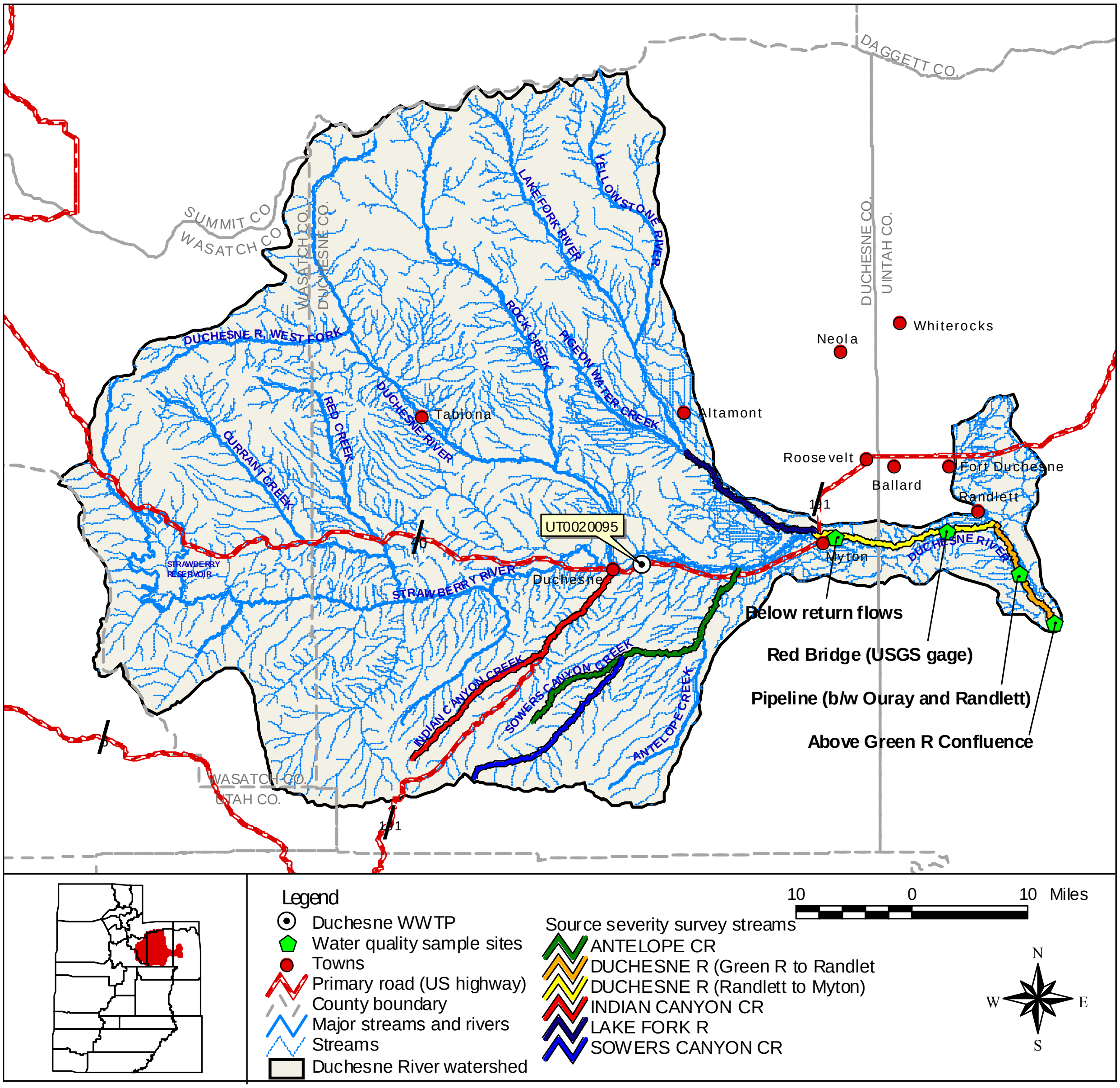

Figure 5-2. Locations of 2005 watershed field surveys in the Duchesne River watershed

The TMDLs for this watershed relied on available instream data to evaluate TDS loading at key locations in the watershed to determine the existing loading, loading capacity, and the necessary load reductions to meet water quality standards. Because this approach does not directly evaluate relative contributions from sources, the watershed field survey was conducted to identify and characterize watershed sources for targeted control.

Field assessments of the Duchesne River watershed were conducted during the weeks of May 30, 2005, and September 19, 2005, to obtain a better understanding of water quality issues and the potential sources of TDS in the watershed. The assessments were performed through on-the-ground surveys for the majority of the Duchesne River watershed. During the on-the-ground surveys, potential sources of pollution were identified and located using a GARMIN 3+ GPS with up to 5- foot accuracy. These sources included areas of surface disturbance, irrigation activities, natural sources, streambank erosion and destabilization, roadways, oil and gas activities, and other activities. Potential opportunities for implementation were also identified during the field assessments. Table 5-1 summarizes the potential sources and severity for each cause of impairment identified during the field surveys of the Duchesne River watershed. The following sections describe the various potential sources of TDS loading in the listed segments of the Duchesne River watershed. Information summarized in the following sections is based on results of the watershed surveys as well as subsequent input from local stakeholders.

Table 5-1. Summary of expected TDS sources identified during the 2005 watershed field surveys

Name	Sources	Severity
Indian Canyon Creek (confluence with Strawberry River to headwaters)	Natural conditions (geology, elk)	High
	Livestock practices (corral, animal feeding area)	Moderate
	Dirt roads (winter salting)	Low to moderate
Sowers Canyon Creek (main tributary to Antelope Creek)	Streambank destabilization	Moderate to high
	Oil and gas activities	Moderate to high
	Natural conditions (geology)	Moderate to high
Antelope Creek (confluence with Duchesne River to headwaters)	Oil and gas activities	Moderate to high
	Natural conditions (geology)	Moderate to high
	Irrigation practices	Low to moderate
Lake Fork River (confluence with Duchesne River to Pigeon Water Creek confluence)	Natural conditions (geology)	Moderate
	Irrigated agriculture	Moderate
	Pasture lands	Moderate
	Cattle grazing	Moderate
	Oil and gas activities	Moderate
Duchesne River (confluence with Green River to Randlett)	Flood irrigation	High
	Open drainage canals	High
	Natural conditions (geology)	Moderate to high
Duchesne River (Randlett to Myton)	Open drainage canals	High
	Irrigation practices	Moderate to high
	Natural conditions (geology)	Moderate
	Cattle grazing	Moderate
	Flow diversions	Moderate
	Streambank destabilization	Low to moderate

5.3.1 Indian Canyon Creek (Confluence with Strawberry River to Headwaters)

The Mancos/Duchesne River formation geology of Indian Canyon Creek might account for the majority of the TDS loading in this subwatershed. There appeared to be good riparian vegetation, although there was evidence of localized streambank destabilization associated with a few livestock corrals that might be a moderate source of TDS loadings. During a few weeks in the springtime, a corral on Indian Canyon Creek is used for calving. Frequently used dirt roads located approximately 150 feet from the creek could also be a low to moderate source of TDS loading. The presence of beaver dams in the lower sections of Indian Canyon Creek were also observed by local stakeholders. According to local stakeholders, beaver dams have filtered out much of the sediment that would have been delivered to the Strawberry River.

The Utah Division of Wildlife Resources has identified an elk herd of approximately 800 head in the Anthro Wildlife Management Unit, which can contribute to the high TDS loadings, in addition to the more than 60 head of cattle that graze in the area. The elk herd can also directly impact the riparian zone from their rooting and wallowing activities, which can lead to erosion and higher TDS loadings.

Based on full water rights (which is atypical due to over-appropriation), approximately 248 acres of irrigated land exist in the Indian Canyon Creek watershed. Stakeholders indicate that irrigation diversions reduce flows by approximately 90 percent in Indian Canyon Creek and that, in dry years, groundwater is the main source of flow in the creek.

5.3.2 Antelope Creek (Confluence with Duchesne River to Headwaters)

In the lower reaches of Antelope Creek, there did not appear to be a lot of water being diverted from the creek. Antelope Creek flows are not continuous. Antelope Creek is dry-dammed approximately 3 miles upstream of UDEQ's sampling site at U.S. Highway 40 (493423). A portion of the flow at this station represents seepage from the Grey Mountain Canal, potentially impacting water quality at this site. All the lands along U.S. 40 from Antelope Creek west to the town of Duchesne are irrigated, according to the field surveys. Stakeholders noted that approximately 430 acres of irrigated land exist in the Antelope Creek watershed, with approximately 230 acres that have been treated with salinity control measures located near the mouth of the creek. Stakeholders also indicate that irrigation diversions reduce flows by approximately 90 percent in Antelope Creek and that, in dry years, groundwater is the main source of flow in the creek. Irrigation return flows might be a low to moderate source of TDS in the creek. Oil and gas developments in this subwatershed are required to haul out their produced water. However, there is some evidence that illicit discharges occurred in the past because regulatory fines have been levied. The discharges might be a significant (moderate to high) source of TDS. Oil field operations have improved in recent years, and produced water discharges are infrequent and not consistent with standard practices.

5.3.3 Sowers Canyon Creek (Main Tributary to Antelope Creek)

Sowers Canyon Creek is a main tributary to Antelope Creek. High cut banks and high sediment loads were observed in the creek during the survey in May/June 2005. This creek might be a moderate to high source of TDS loading to Antelope Creek. Oil and gas developments in the upper watershed, geologic sources, and gypsum outcrops might also be moderate to high sources of TDS in this creek.

5.3.4 Lake Fork River (Confluence Duchesne River to Pigeon Water Creek Confluence)

In this watershed, there are some irrigated agriculture lands, pasture lands, and cattle grazing, which might be moderate sources of TDS. On the upper mesa lands and near the Pigeon Water Diversion, there is oil and gas development, which might also be a moderate source of TDS to the creek. Mancos shale outcrops on the Lake Fork River (with a cobble overlay) was identified by local stakeholders as an eroding feature during high flow events, which may be causing TDS exceedances in this river. High deposition of salts on the ground surface essentially seal the soil, preventing percolation of precipitation. This action greatly enhances the effects of runoff, increasing the velocity of runoff, developing sheet flows, and increasing TDS loading.

5.3.5 Strawberry Aqueduct and Collection System Wetland Mitigation Area (Tribal Lands)

The wetlands mitigation area covers approximately 3,200 acres of wetlands on tribal lands, of which approximately 2,700 acres occur in riparian areas. Flood irrigation and open drainage canals discharge into the Duchesne River and its tributaries and might be significant sources of TDS loading. Flood irrigation is prevalent on tribal lands. Canal systems are mainly open, resulting in high evaporative losses and deep percolation into the shallow alluvial aquifer. In the riverside oxbow area of the Strawberry Aqueduct and Collection System (SACS) project, drainage canals were historically constructed to drain ponded water and lower the water table.

5.3.6 Duchesne River (Randlett to Myton)

From Randlett to Myton, there are some irrigated lands and cattle grazing. These practices might be moderate sources of TDS to the river. The overall riparian condition looked healthy in this area. There was some salt accumulation on patches of bare dirt.

From Randlett to Myton, there were several agricultural drains and irrigation return flows to the Duchesne River. In the upper stretches of the river near the town of Myton, there was a mostly intact riparian corridor; however, there were some high-cut banks along the river from previous high-flow events. Other areas downstream along the riparian corridor had open areas adjacent to the river, extensive grazing, and some bank instability. Some streambanks showed evidence of trampling. In addition, there were some undercut banks, and salt accumulation was noted on some streambanks.

5.3.7 Duchesne River (Confluence with Green River to Randlett)

The lands are mainly agricultural or undeveloped along the segment of the Duchesne River from its confluence with the Green River to Randlett. There were a few oil and gas developments observed on the mesa tops. Mancos Shale dominates the geology in this area, with outcrops of the formation approximately 150–200 feet from the river. Geology might be a significant (moderate to high) source of TDS loading to this stretch of the river. During the field survey in September 2005, the Ouray School Canal diversion appeared to divert approximately 60 percent of the flow that was apparently replenished by baseflow contributions within several hundred yards downstream. Further downstream to the town of Ouray (above the confluence with the Green River), many irrigation return flow drains were also noted along the Duchesne River's riparian corridor.

5.4 Summary

Observed TDS concentrations support the conclusion that irrigation activities (flood irrigation, irrigation return flows, open canals, and flow diversions) are moderate and major sources of anthropogenic TDS loading in the watershed. Although, as part of the Colorado River Basin Salinity Control Program, a majority of irrigated lands, particularly on Antelope Creek, have converted from surface to pressurized irrigation systems, reducing irrigation return flows and deep percolation.
Oil and gas developments, surface disturbance, roads and livestock activities are also identified as sources of human-induced TDS loading in the Duchesne River watershed.

"Natural condition" implies the absence of human manipulation. The hydrology of the watershed currently and historically has been extensively manipulated and altered for agricultural use. Without a reference condition, it is impossible to determine what effect that alteration and use has had on water quality and to what degree natural and anthropogenic sources influence TDS. Given the interconnectedness of the surface and groundwater hydrology and the watershed's natural salinity, there is a lot of complexity associated with identifying the source of TDS loading in these watersheds.

The watershed characteristics that make it difficult to identify natural conditions also make it difficult to isolate specific areas or sources of TDS loading. The watershed is characterized by an extensive network of diversion canals and irrigation ditches that divert and transport water within the watershed as well as into and out of the watershed. It would be impossible to appropriately establish representative conditions and evaluate loadings and responses at specific points in the complex stream network of Indian Canyon Creek, Antelope Creek, Lake Fork River, and the Duchesne River. Therefore, the TMDL analyses will focus on the watershed as a whole, not isolating TDS loadings from specific subwatersheds, areas, or sources. The TMDL analyses use data collected at the mouths of each of the watersheds and will establish gross loadings for the entire watersheds.

6. IDENTIFICATION OF LOADING CAPACITY

The loading capacity is the amount of pollutant that can be assimilated by a waterbody while still attaining and maintaining water quality standards. The loading capacity is equivalent to the TMDL and is allocated among the wasteload allocations (point sources), load allocations (nonpoint sources), and a margin safety. This section discusses the estimation of the loading capacity and existing TDS loadings in the impaired segments of the Duchesne River and Lake Fork River. After initial loading calculations, UDEQ decided to develop site-specific criteria for Antelope Creek and Indian Canyon Creek. Therefore, this section does not discuss load calculations for those creeks. Site-specific criteria for Antelope Creek and Indian Canyon Creek are discussed in Section 8.

6.1 Technical Analysis

Methods available for estimating existing and allowable loadings include watershed models and statistical approaches using existing water quality data. A watershed model consists of a series of algorithms applied to watershed characteristics and meteorological data to simulate naturally occurring land-based processes over an extended period of time, including hydrology and pollutant transport. Many watershed models are also capable of simulating instream processes using the land-based calculations as input. Once a model has been adequately set up and calibrated for a watershed, it can be used to quantify the existing loading of pollutants from subwatersheds or from land use categories. Models can also be used to assess the potential benefits of various restoration scenarios (e.g., implementation of BMPs).

Watershed models used to simulate hydrology and pollutant transport over large spatial scales often are not able to accurately incorporate the complexities associated with significant anthropogenic alterations to watershed-scale hydrological processes. These alterations can include diversions, canals, and other withdrawals or discharges to surface or ground water. The large number of diversions, canals, and other irrigation pathways has significantly altered the hydrology of the Duchesne River watershed (see Figure 2-14). Existing watershed models have limited ability to simulate such a system. Because of the significant challenges and data needs associated with setting up and calibrating a watershed model for the Duchesne River watershed, a statistical load duration approach was used to develop the loading capacities and existing loadings within the watershed.

The load duration approach relies on instream data, allowing direct comparison between existing conditions and conditions meeting water quality standards. It also accurately identifies the allowable and existing loads, uses data for all flows and loading conditions, and provides insight into critical conditions. The approach also provides consistency with other TDS TMDLs calculated in Utah, including those in the Virgin River watershed, Sevier River watershed and Uinta River watershed. However, disadvantages to using a statistical approach are that it provides limited information regarding the relative sources of the loads and does not allow one to simulate the impact of BMPs. Therefore, the TMDL was supported by field surveys to identify and characterize sources in the watershed and focus potential implementation efforts. Section 5 discusses the source assessment and Section 8 discusses potential implementation activities for the watershed.

The load duration approach for the Duchesne River watershed TMDLs included the following steps:

1. A flow duration curve for each river segment was developed using the available flow data. This was done by generating a flow frequency table that consisted of ranking all the observed flows from the least observed flow to the greatest observed flow and plotting all the values.
2. The flow duration curve was translated into a load duration curve (TMDL graph) by multiplying each flow by the water quality standard and plotting the resulting points.

3. Each observed TDS value was converted to a daily load by multiplying the sample concentration by the corresponding average daily flow on the day the sample was taken. The load was then plotted on the TMDL graph.
4. Loads plotted above the curve represent exceedances of the water quality standard. Loads plotted below the curve represent compliance with standards and represent allowable daily loads.
5. The median observed load for each flow range was compared to the allowable load for that range to identify necessary load reductions to meet water quality standards. The allowable load for each range was calculated using the median flow for that range and the TDS criterion of 1,200 mg/L.

Through careful interpretation the load duration approach can help identify the major issues contributing to the impairment and differentiate between various types of sources (Figure 6-1). Loads that plot above the curve in the 1 percent to 15 percent flow ranges (low flow conditions) are likely indicative of constant discharge sources. Those plotting above the curve between 30 percent and 90 percent likely reflect precipitation driven contributions. Those plotting above the curve in the less than 1 percent and greater than 90 percent flow ranges reflect hydrologic conditions of extreme drought or flood, respectively.

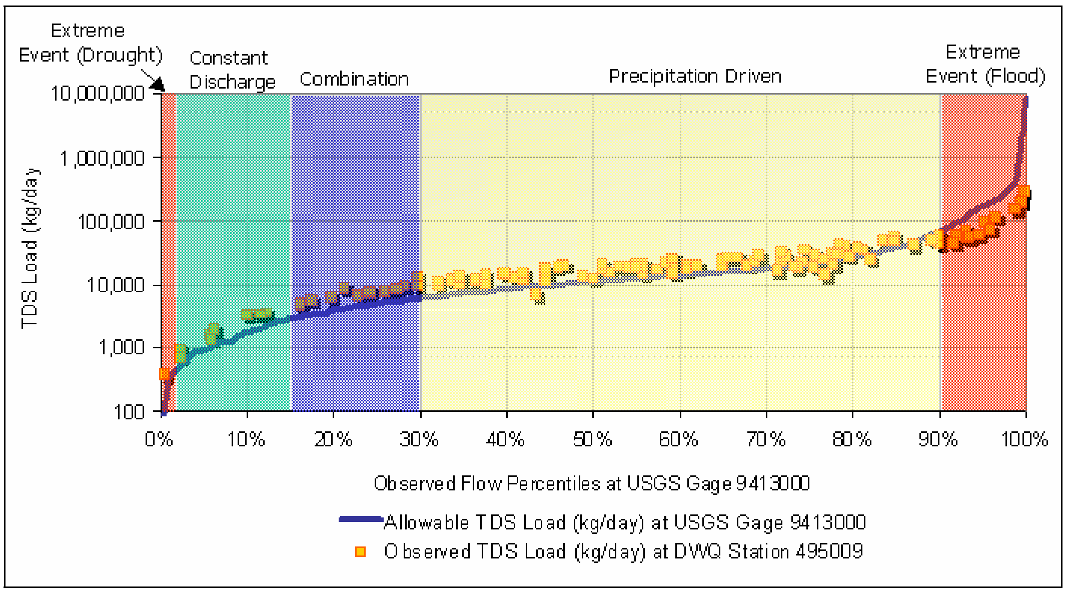

Figure 6-1. Example of a load duration curve

6.2 Stations and Data Used in the Analysis

Ideally, this load duration approach is applied at monitoring stations for each listed segment with corresponding TDS and flow data. It is important to have data for all flow conditions occurring in the waterbodies and to have sufficient matching flow and TDS data across all flow ranges. While there are sufficient datasets of TDS at a number of stations throughout the watershed and on listed segments, there are limited flow data. Table 6-1 and Figure 6-2 present the UDEQ stations and corresponding USGS gauges evaluated for use in the TMDL calculations. Water quality stations used to calculate TMDLs were selected on the basis of their locations on impaired segments. To characterize the water quality representative of the entire impaired subwatershed, the farthest downstream station was selected.

Table 6-1. Water quality stations and flow gauges evaluated for use in calculating the TMDLs

Water Quality Station			Corresponding Flow Gauge and Measurements		
ID	**Description**	**Period of Record**	**ID**	**Description**	**Period of Record**
493405	Duchesne R above confluence with Green R	8/1949–5/2001	USGS 9302000[1] (upstream)	Duchesne R near Randlett	10/1942–9/2003
493410	Duchesne R near Randlett	8/1979–6/2001	USGS 9302000[1]	Duchesne R near Randlett	10/1942–9/2003
493574	Lake Fork R above confluence with Duchesne R	8/1979–6/2001	USGS 9294500	Lake Fork R near Myton	3/1910–10/1981
			UDEQ 493574	Lake Fork R above confluence with Duchesne R	3/1985–6/2001

[1]The USGS gauge at Randlett (9302000) was moved in 2004 due to difficulties in maintaining a rated cross section, icing, and channel configuration (USFWS, 2005). The change in physical conditions surrounding the gauge might have affected flow measurements.

Of the three TMDL water quality stations only two had both continuous flow data capturing all flow conditions and matching TDS data across the observed range (UDEQ stations 493405, Duchesne River above the confluence with the Green River, and 493419, Duchesne River at Myton). While the Lake Fork River flow gauge (9294500) does have a long range of continuous flow data, the data record ends in 1981. The majority of water quality data was collected at this station after this time period, and as a result, matching water quality data exist only for the most recent flow observations (1979-1981). To supplement the available flow data at water quality stations 493574 (Lake Fork River), instantaneous flow measurements calculated by UDEQ during water quality data collection were appended to the continuous data available from USGS gauging stations.

Instantaneous flow data available for water quality station 493574 (Lake Fork River) were limited, with 28 discrete measurements taken between 1985 and 2001. The wide range of flow values captured by the instantaneous measurements at station 493574 (3-1,005 cfs) and the fact that the flow measurements were often taken in conjunction with the collection of water quality data provided a sufficient range of matched flow and water quality data for TMDL calculation at Lake Fork River.

Table 6-2 presents the selected stations and data used in the TMDL calculations. The periods of record for the TMDL calculations were selected on the basis of available data and consideration of historical and existing watershed conditions and activities. A longer period of record of matching flow and water quality is preferable for load duration analyses to get a stable representation of hydrology. However, it is important that data used in the TMDL analysis reflect existing conditions to identify realistic load reductions and support appropriate implementation recommendations. The Duchesne River watershed has undergone considerable changes historically that have affected flow and TDS levels, including extensive hydrologic modification and more recently the implementation of salinity control projects. The general timeline extending from the late 1970s to the present was chosen for the TMDLs to capture station-specific variations indicated in their available datasets. This timeframe provides a longer period of record to capture the greatest amount of water quality and flow data. Although studies have indicated that there is a decreasing trend in TDS concentrations in the watershed in recent years, the TMDL timeframe (late 1970s to the present) includes a longer period of record (likely including higher TDS levels than present day) providing a more appropriate amount of data and providing a margin of safety to the analysis.

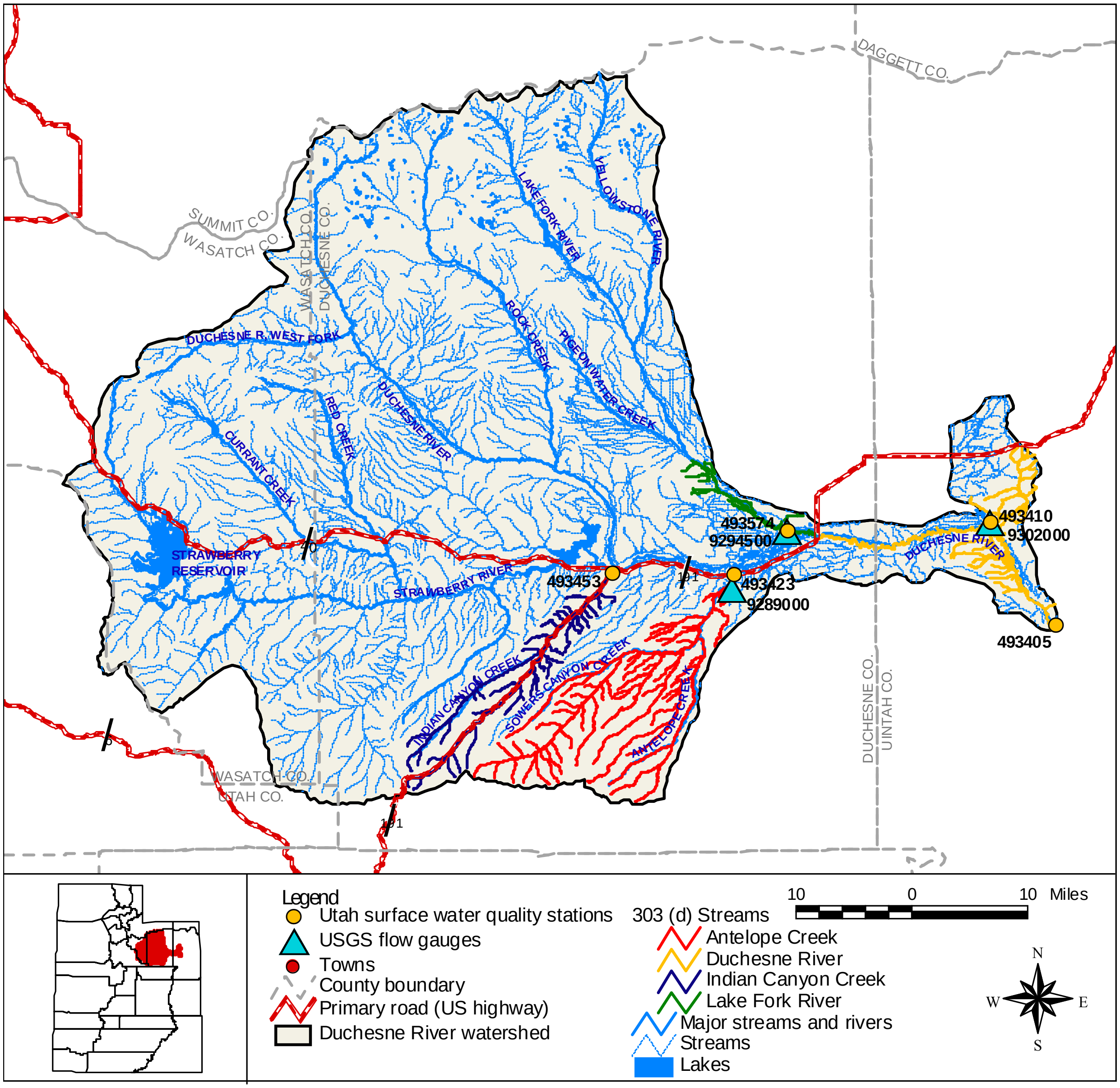

Figure 6-2. Location of water quality stations on impaired segments and nearby USGS gauges

Table 6-2. Stations and flow gauges used in calculating the TMDLs

Water Quality Station	Corresponding Flow Data	Impaired Segment	Period of Record for Calculation
493405	USGS 9302000	Duchesne River (Confluence with Green River to Randlett)	8/1979–9/2003
493410	USGS 9302000	Duchesne River (Randlett to Myton)	8/1979–9/2003
493574	USGS 9294500 + 493574	Lake Fork River (Confluence with Duchesne River to Pigeon Water Creek)	8/1979–10/1981 (continuous) + 3/1985–6/2001 (discrete)

The TMDL analyses were conducted using an automated spreadsheet tool developed by Tetra Tech for previous load duration TMDLs. The tool organizes flow and pollutant concentration data and automatically matches the water quality data with the flow on that date to calculate observed loads. The tool provides a summary report including distribution of data among the flow ranges, water quality and flow trends, load duration plots, and a TMDL summary table of allowable and existing loads by flow range. Section 7 summarizes the results of the load duration analyses, including TMDLs and existing loads, for each impaired segment in the Duchesne River watershed.

7. TMDL ALLOCATIONS

A TMDL is composed of the sum of individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the water quality of the receiving waterbody. Conceptually, this definition is denoted by the equation

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS.$$

The TMDL, equivalent to the loading capacity, is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. This section documents the TDS TMDLs calculated for the following impaired segments:

- Duchesne River from the confluence with Green River to Randlett
- Duchesne River from Randlett to Myton
- Lake Fork River

Site-specific criteria for TDS are developed for Antelope Creek and Indian Canyon Creek and are presented in Section 8.

The TDS TMDLs for the Duchesne River watershed are expressed on a mass loading basis. The following sections present the existing loads and TMDLs for TDS in Lake Fork River and the two listed segments of the Duchesne River. It should be noted that, for some of the subwatersheds, load duration figures indicate that there are several observed loads exceeding the allowable loading for flow ranges that do not require load reductions (as summarized in the tables). The load duration analysis for these TMDLs selects the median observed daily load of all observed loads in a flow range as the "representative" load for that flow range. Therefore, the median load might not exceed the allowable load, while several single observations show exceedances.

Table 7-1 summarizes the TDS load reductions identified to meet the TMDL allocations for each flow range for the impaired segments in the Duchesne River and Lake Fork River. Details on the allowable loads and existing loads for each segment are included in the following sections.

Table 7-1. Summary of necessary TDS load reductions for Duchesne River and Lake Fork River

Flow Percentile Ranges	Duchesne River (Green River to Randlett)	Duchesne River (Randlett to Myton)	Lake Fork River
0-10	12.3%	29.4%	0.0%
10-20	8.4%	16.7%	0.0%
20-30	14.6%	13.1%	0.0%
30-40	0.0%	0.0%	0.0%
40-50	0.0%	0.0%	0.0%
50-60	0.0%	0.0%	0.0%
60-70	0.0%	0.0%	0.0%
70-80	0.0%	0.0%	0.0%
80-90	0.0%	0.0%	0.0%
90-100	0.0%	0.0%	4.2%

Because of the years of hydrologic modification and the use and reuse of water for irrigation and other uses in the Duchesne River watershed, it is difficult to separate anthropogenic influences on instream TDS concentrations from those of natural conditions caused by saline soils and resulting TDS loads in runoff and groundwater inputs. If the load reductions identified in this TMDL are attained from recent or future salinity control projects and water quality standards are still violated, this TMDL will be reviewed or site-specific water quality standards will be developed based on additional data collected. Regardless of the short-term effect on instream flows and concentrations, the available and recommended control efforts should improve irrigation efficiencies and water quality will ultimately benefit.

7.1 Duchesne River (Confluence with Green River to Randlett)

This section presents the wasteload and load allocations for TDS in the impaired segment of the Duchesne River from the confluence with the Green River to Randlett.

7.1.1 Wasteload Allocation

Because there are no point sources discharging TDS to this segment of the Duchesne River, the wasteload allocation is 0 kg/day.

7.1.2 Load Allocation

Water quality data at station 493405 (Duchesne River above confluence with Green River) and flow data at the USGS gauge 9302000 (Duchesne River near Randlett) were used to estimate existing and allowable TDS loads for this segment of the Duchesne River. The results of the load duration curve analysis are presented in Figure 7-1 and Table 7-2. They indicate that TDS loads above the loading capacity occur during low flow periods—0–10, 10–20, and 20–30 percentile ranges. The greatest load reduction (approximately 15 percent) is needed for the 20–30 percentile flow range. Critical conditions typically occur during spring (April and May) and fall (September and October) when streamflows are decreased and TDS concentrations are high. Because there are no point sources in this watershed, all allowable loads listed in Table 7-2 are allocated as gross load allocations to nonpoint and background sources in the watershed.

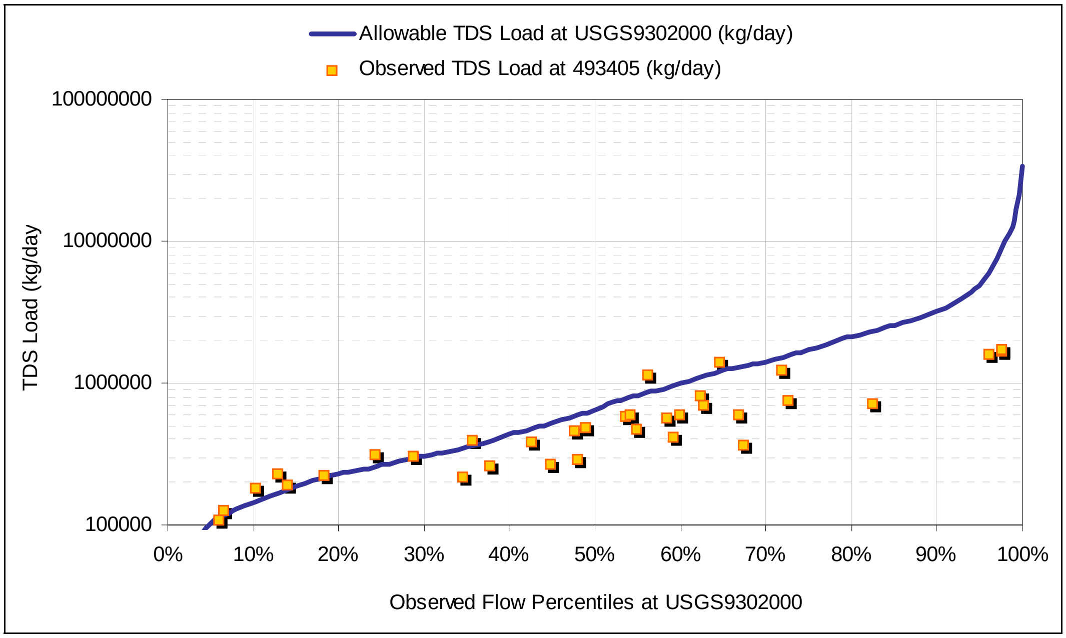

Figure 7-1. TDS load duration curve at station 493405 (Duchesne River above confluence with Green River)

Table 7-2. Observed and allowable TDS loads at station 493405

Flow Percentile Ranges	34-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (kg/day)	Observed Load (kg/day)	Estimated Reduction (%)
0-10	2	35.00	102,756	117,130	12.3%
10-20	4	64.00	187,897	205,238	8.4%
20-30	2	90.00	264,230	309,335	14.6%
30-40	3	120.00	352,307	260,316	0.0%
40-50	5	180.00	528,460	388,418	0.0%
50-60	7	280.00	822,049	580,749	0.0%
60-70	5	415.00	1,218,395	702,857	0.0%
70-80	2	584.50	1,716,028	984,135	0.0%
80-90	1	873.00	2,563,033	719,660	0.0%
90-100	3	1,667.00	4,894,130	1,673,458	0.0%

7.2 Duchesne River (Randlett to Myton)

This section presents the wasteload and load allocations for TDS in the impaired segment of the Duchesne River from Randlett to Myton.

7.2.1 Wasteload Allocation

There is one permitted source discharging to this segment of the Duchesne River—the Duchesne City Wastewater Treatment Plant (UT0020095). The plant discharges only intermittently to the river, sometimes only once or twice a year. Because of the sporadic and infrequent discharges of this facility, it is difficult to identify an appropriate allowable TDS load. It is also difficult to evaluate the discharge in the context of the allowable loads for different flow ranges. Because the Duchesne City Wastewater Treatment lagoons are in the Colorado River drainage, the permittee must conform to the Colorado Salinity Forum Policy, which states that the effluent shall not exceed the culinary intake water supply by more than 400 mg/L TDS as a maximum monthly average and a load limit of less than 1 ton per day. There is no daily or weekly average for effluent limitations for TDS for this facility. Therefore, the wasteload allocation for the Duchesne City Wastewater Treatment facility is 1 ton of TDS per day.

7.2.2 Load Allocation

Water quality data at station 493410 (Duchesne River near Randlett) and flow data at the USGS gauge 9302000 (Duchesne River near Randlett) were used to estimate existing and allowable TDS loads for this segment of the Duchesne River. The results of the load duration curve analysis are presented in Figure 7-2 and Table 7-3. They indicate that TDS loads above the loading capacity occur primarily during low flows. The highest load reduction (approximately 29 percent) is estimated for the 0–10 percentile flow range. Reductions are also needed for the 10–20 and 20–30 percentile flow ranges. Critical conditions typically occur during spring (April and May) and fall (September, October and November) when streamflows are decreased and TDS concentrations are high. Because the wasteload allocation for this watershed is established as a concentration, all allowable loads listed in Table 7-3 are allocated as gross load allocations to nonpoint and background sources in the watershed.

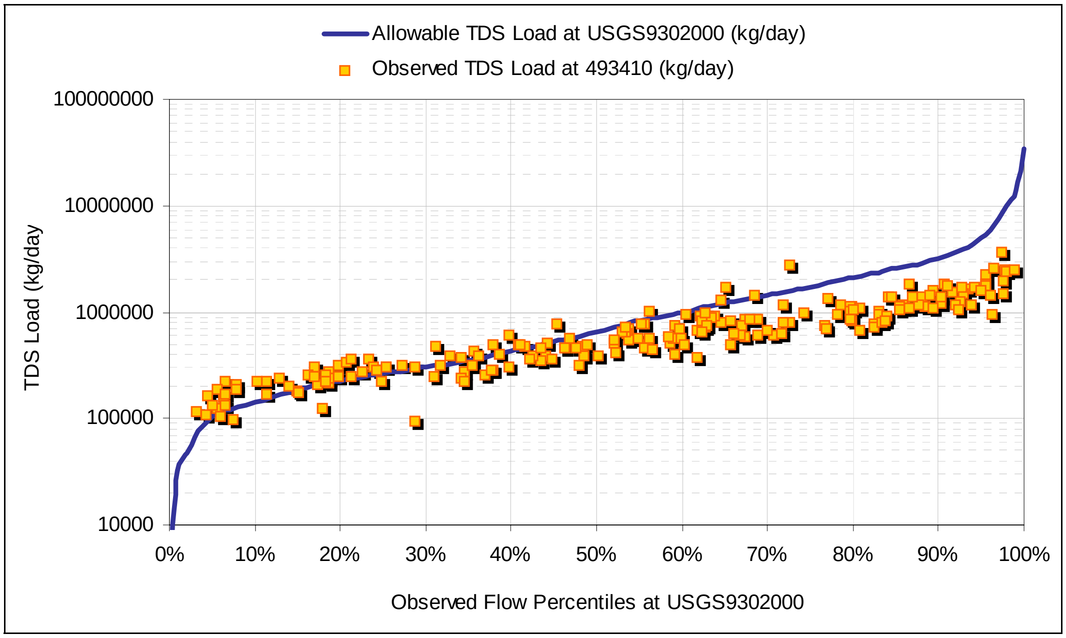

Figure 7-2. TDS load duration curve at station 493410 (Duchesne River near Randlett)

Table 7-3. Observed and allowable TDS loads at station 493410

Flow Percentile Ranges	204-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (kg/day)	Observed Load (kg/day)	Estimated Reduction (%)
0-10	14	35.00	102,756	145,650	29.4%
10-20	19	64.00	187,897	225,584	16.7%
20-30	13	90.00	264,230	303,953	13.1%
30-40	18	120.00	352,307	316,271	0.0%
40-50	19	180.00	528,460	464,849	0.0%
50-60	25	280.00	822,049	570,091	0.0%
60-70	27	415.00	1,218,395	824,966	0.0%
70-80	18	584.50	1,716,028	890,984	0.0%
80-90	25	873.00	2,563,033	1,086,431	0.0%
90-100	26	1,667.00	4,894,130	1,683,660	0.0%

7.3 Lake Fork River (Confluence with Duchesne River to Pigeon Water Creek)

This section presents the wasteload and load allocations for TDS in Lake Fork River.

7.3.1 Wasteload Allocation

Because there are no point sources discharging TDS in the Lake Fork River watershed, the wasteload allocation is 0 kg/day.

7.3.2 Load Allocation

Water quality data at station 493574 (Lake Fork River above confluence with Duchesne River) and flow data at the USGS gauge 9294500 (Lake Fork River near Myton) and UDEQ station 493574 were used to estimate existing and allowable TDS loads for Lake Fork River. The results of the load duration curve analysis are presented in Figure 7-3 and Table 7-4. Because of the limited TDS data collected at the Lake Fork River station, data are not available for every flow range. Therefore, the observed loads for the represented flow ranges were used to estimate observed loads for the “missing” flow ranges. Figure 7-4 presents the relationship between flow percentile and observed daily TDS load. The equation representing this relationship was used to estimate the loads for the 60–70 percentile flow range.

The load duration results indicate that TDS loads above the loading capacity occur mostly during low flows and occasionally in mid-range and high flows. Critical conditions in the Lake Fork River typically occur during early spring (March, April and May) and fall (October and November) when streamflows are decreased and TDS concentrations are high. Although some observed loads during these times of lower flows plot above the TMDL curve, the median observed loads do not exceed the allowable load in most flow ranges. The only flow range requiring a load reduction (approximately 4 percent) is the 90–100 percentile flow range. Some instantaneous flow measurements in the UDEQ data were substantially higher than most flows included in the USGS flow record for this station. The higher observed flows resulted in higher observed TDS loads and, therefore, a relatively higher median observed TDS load for the 90–100 percentile flow range. Implementation actions for this segment should still focus on decreasing TDS loading during lower flows as well as higher flows. Because there are no point sources in this watershed, all allowable loads listed in Table 7-4 are allocated as gross load allocations to nonpoint and background sources in the watershed.

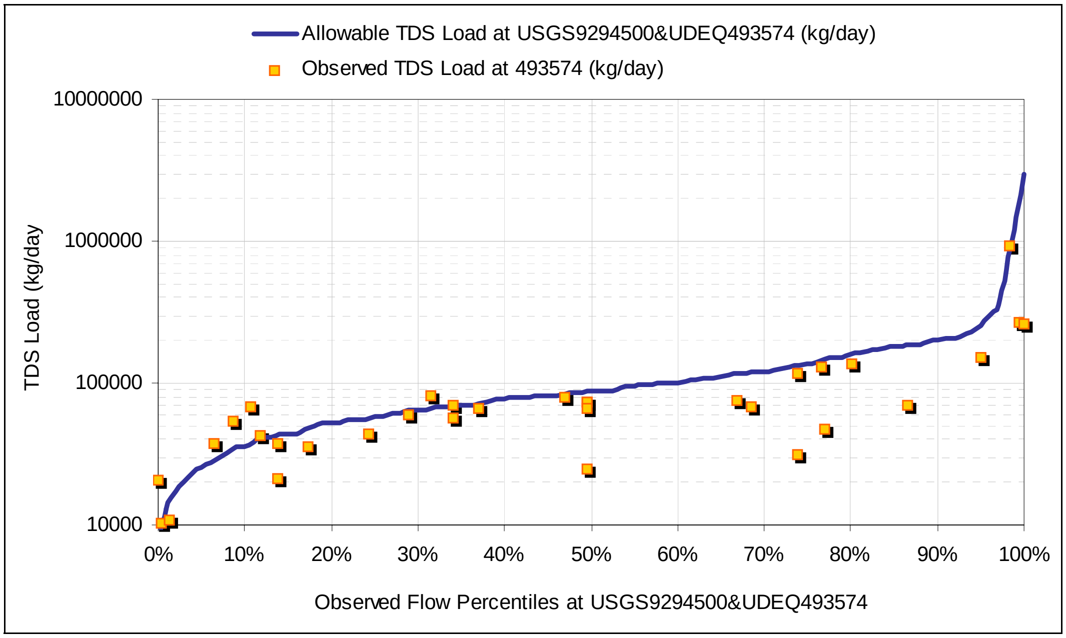

Figure 7-3. TDS load duration curve at station 493574 (Lake Fork River above confluence with Duchesne River)

Table 7-4. Observed and allowable TDS loads at station 493574

Flow Percentile Ranges	34-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (kg/day)	Observed Load (kg/day)	Estimated Reduction (%)
0-10	5	8.59	25,219	20,735	0.0%
10-20	5	15.00	44,038	37,212	0.0%
20-30	2	20.00	58,718	51,486	0.0%
30-40	4	24.00	70,461	68,076	0.0%
40-50	5	28.00	82,205	73,544	0.0%
50-60	1	32.30	94,829	75,940	0.0%
60-70[1]	2	38.00	111,564	71,575	0.0%
70-80	4	46.00	135,051	82,291	0.0%
80-90	2	62.00	182,025	102,173	0.0%
90-100	4	86.70	254,542	265,612	4.2%

[1]Because no TDS data were available for the 60–70 percentile range, the load duration tool could not calculate an observed load. The observed load for this range was estimated using a relationship between the other flow ranges and their respective observed loads.

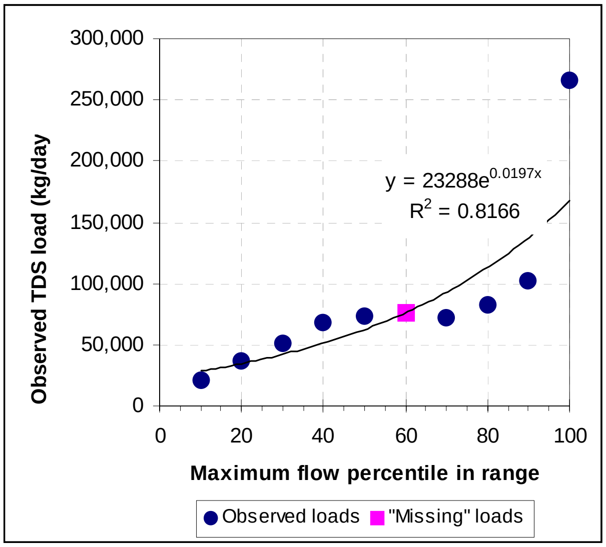

Figure 7-4. Relationship between observed TDS load and flow percentile in Lake Fork River

7.4 Margin of Safety, Critical Conditions, and Seasonality

The Clean Water Act requires that a TMDL include a margin of safety to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The margin of safety can be implicit (e.g., incorporated into the TMDL analysis through conservative assumptions) or explicit (e.g., expressed in the TMDL as a portion of the loading) or a combination of both. An implicit margin of safety was included in the TMDLs for the Duchesne River watershed by using historical TDS data in the TMDL calculations. Watershed studies have indicated that TDS data are exhibiting a decreasing trend at watershed stations, and it is likely that data collected in the 1980s and 1990s reflect higher TDS values than in recent years. Downward trends in TDS are expected to be the result of a variety salinity control practices implemented throughout the watershed since the formation of the Colorado River Salinity Forum. Using data that reflect conditions of fewer controls and higher TDS loading provides a conservative estimate of the “representative” TDS loads used to identify load reductions for the evaluated flow ranges.

TMDLs are also required to consider seasonal variations and critical conditions in the analysis. TDS loadings in the Duchesne River watershed vary seasonally due to variations in weather and source activity. To account for this seasonality, all of the TMDLs present existing and allowable loads by flow percentile, which typically captures seasonal variations in the watershed (i.e., lower flows typically occur in the fall and winter and higher flows occur in the spring and summer). The TMDL approach also considers critical conditions by evaluating loads by defined flow ranges. The approach identifies conditions (e.g., low flows) experiencing impairment and needing load reductions and, therefore, the times and conditions in which to focus implementation efforts.

8. SITE-SPECIFIC CRITERIA

Development of site-specific criteria is recommended for the 303(d)-listed segments of Indian Canyon Creek and Antelope Creek.

The Utah Standards of Quality for Waters of the State provide for development of site-specific TDS standards where the adjustment does not impair designated beneficial uses.

> "Total dissolved solids (TDS) limits may be adjusted if such adjustment does not impair the designated beneficial use of the receiving water. The TDS standards shall be at background where it can be shown that natural or un-alterable conditions prevent its attainment. In such cases rulemaking will be undertaken to modify the standard accordingly."

In addition, the EPA Region 8 memorandum *Use Attainability Analysis and Ambient Based Criteria* (Moon, 1997) provides guidance for developing site-specific criteria. The memorandum recognizes that ambient-based criteria are usually proposed for sites where the existing water quality (exceeding statewide water quality criteria) is perceived to be "natural" or, alternatively, resulting from "irreversible human-induced conditions." Sites where the local geology may result in naturally elevated concentrations of salts or minerals are those most often proposed as sites warranting ambient-based criteria.

Data are not available for Indian Canyon Creek and Antelope Creek during times of "natural" conditions—prior to the manmade changes to support irrigation in the area. It is assumed that conditions in these watersheds can improve to some extent, based on slight decreases in TDS concentrations over the last decades. However, it is unlikely that these watersheds can feasibly meet the current TDS water quality criterion of 1,200 mg/L due to a combination of naturally saline soils and irreversible modifications from irrigation activities. Of the approximately 62,000 acres included in the Indian Canyon Creek watershed, only 248 acres (<1 percent) are irrigated. Similarly, less than 1 percent of the approximately 800,000 acres of Antelope Creek watershed are irrigated and a majority of the 430 irrigated acres in this watershed have already been treated with salinity control projects.

The proposed site-specific TDS criteria for Antelope Creek and Indian Canyon Creek are based on the 90^{th} percentile concentration of available ambient water quality data. This approach is consistent with other TDS site-specific criteria developed in Utah (e.g., Sevier River, Price River, San Rafael River and Virgin River). The proposed criteria are listed in Table 8-1.

Table 8-1. Recommended site-specific TDS criteria for Indian Canyon Creek and Antelope Creek

Creek	Proposed Site-Specific TDS Criterion (mg/L)	UDEQ Station Used in Calculation	Station Location
Indian Canyon Creek	2,183	493453	Above confluence with Strawberry River
Antelope Creek	2,655	493423	At U.S. 40 Crossing

As required by Utah Water Quality Standards, the recommended site-specific criteria will support the affected designated uses of irrigation and stock watering. Iowa Department of Natural Resources conducted a review of available water quality standards and literature information regarding levels of TDS and the effect on waterbody uses (http://www.iowadnr.com/water/standards/files/tdsissue.pdf). Toxicity test data presented in the paper indicate that the safe upper limits of TDS in water consumed by beef cattle and dairy cattle are 10,000 mg/L and 7,150 mg/L, respectively. In addition, the Canadian Water Quality Guidelines identifies 3,000 mg/L as the maximum acceptable limit for livestock drinking water (CCREM, 1987) and The National Academy of Sciences *Water Quality Criteria 1972* (NAS and

NAE, 1973) indicates that if TDS is between 1,000 – 2,999 mg/L, the waters should be satisfactory for all classes of livestock and poultry. They may cause temporary and mild diarrhea in livestock not accustomed to them or watery droppings in poultry, but should not affect their health or performance.

The site-specific criteria are also expected to support the water use for crop irrigation. Ayers and Westcot (1994) identified the crop tolerance for more than 70 different field crops related to the salinity of irrigation water. Electrical conductivity values are provided for crop yield potentials of 50 percent, 75 percent, 90 percent and 100 percent. Observed TDS and electrical conductivity measurements from field samples in Indian Canyon Creek and Antelope Creek were used to establish a regression equation of the two parameters (R^2=0.999) for each stream to identify equivalent electrical conductivity values for the proposed TDS criteria. The conductivity values were then compared to the information in Ayers and Westcot (1994), indicating a resulting crop yield of approximately 80 percent for both streams, based on information for alfalfa, a dominate crop in the watersheds.

9. POTENTIAL CONTROL ACTONS

This section describes potential activities that can be implemented to achieve the load reductions described in the previous section. Identifying possible implementation activities described below and in Appendix E was a focus of the source assessment field work in 2005.

Many of the impairments in the Duchesne River watershed occur during low-flow conditions when pollutants tend to be concentrated and transport and resident times are decreased. TDS can also be transported to receiving streams during storm-driven flood events. The implementation strategies discussed below are designed to reduce the loadings introduced during storm events and to minimize their impacts during the critical low-flow season. It is important to recognize that because all load reductions are associated with nonpoint sources, implementation of BMPs to control these sources is purely voluntary with no mandatory timeframes instituted.

Control options will preserve current water rights and needs while optimizing use and minimizing deep percolation of irrigation water. If excess irrigation water is applied to cropland and pastureland, the excess proportion percolates below the rooting zone of the crop where it picks up TDS and returns it to the watershed streams, either as surface runoff or groundwater baseflow with elevated TDS concentrations. Because TDS is also washed off watershed surfaces and delivered to receiving streams, potential control options should address surface delivery as well as subsurface delivery of TDS.

Activities to reduce TDS loading throughout the Duchesne River watershed will be a locally led effort. This report does not specifically propose management activities; rather it provides examples of options to reduce TDS loading to watershed streams. These options include the following:

- Increase irrigation efficiency by providing sprinkler irrigation, properly scheduling irrigation turns (if possible), reducing flood length, and land leveling.
- Line canals and ditches with concrete or replacing them with pipe. Seepage losses in canals and ditches can result in TDS laden return flows to receiving streams via springs and drains.
- Construct weirs at turnouts to ensure that proper amounts of water are applied.
- Maintain grassed waterways and construct check dams on return flows.
- Maintain uncultivated buffer strips along streams and channels.

Following implementation of improved irrigation techniques, deep percolation has been found to be reduced by approximately 1 acre foot of water (325,851 gallons) per acre of land treated. In addition to reducing deep percolation of irrigation water, it is anticipated that controlling soil erosion from uplands and streambanks will also reduce TDS loading. Potential control options for reducing soil and streambank erosion include:

- Promote proper grazing management on uplands and riparian areas to maintain sufficient plant cover to protect the soil.
- Improve condition of riparian areas through plantings, grazing management, and development of off stream watering sites.
- Improve streambank stability through establishing deep-rooted woody vegetation and sloping vertical streambanks to allow vegetation to establish.

These TMDLs are developed for a representative flow regime derived from historical flow records. Therefore, the allocated loadings and associated load reductions assume that flow conditions will remain similar to those established in the TMDL. However, it is possible that due to more efficient irrigation techniques being implemented as part of salinity control efforts instream TDS concentrations could increase while total loading would decrease. This could be the result of more efficient water uptake from irrigated lands and less dilution water from flood irrigation return flows. To offset this, the control options for TDS in the Duchesne River watershed should focus on minimizing deep percolation of irrigation water through improving the efficiency of irrigation practices and conveyances. To facilitate the implementation of improved irrigation techniques, additional upstream storage options could be pursued, if possible. The development of new irrigation water storage might lead to better water management and encourage the conversion from flood to sprinkler irrigation techniques. To address the possibility that load reductions could result in increased instream TDS concentrations this TMDL will use an approach that provides for the implementation of load reduction strategies while continuing to collect additional data. Regardless of the short-term effect on instream flows and concentrations, the available and recommended control efforts should improve irrigation efficiencies and water quality will ultimately benefit.

9.1 TDS Sources

The majority of anthropogenic TDS loading in the Duchesne River watershed is associated with nonpoint sources. Table 9-1 lists each of the listed segments and the identified nonpoint sources of TDS in each stream segment with potential BMPs for each. Appendix E describes BMPs in more detail and provides information on additional BMPs for improving water quality in the watershed.

Table 9-1. Expected TDS sources and recommended BMPs for each impaired stream reach in the Duchesne River watershed

Identified Nonpoint Sources	General Recommended BMPs	Specific BMP Practices (See Appendix E)
Indian Canyon Creek (confluence with Strawberry River to headwaters)		
Pastureland	Implement rest-rotation grazing systems. Revegetate streambanks with woody vegetation and/or allow for re-establishment.	Grazing Management, Practice #120 (passive management) Seeding, Practices #221 & Pole/Post Plantings #260 (active management) Exotic Removal Practice #210 (active management) Constructed Wetland, Practice #500 (intense engineering) Watering Facility, Practice #370 (mild engineering)
Dirt roads	Maintain vegetation filter strips along roadsides to act as a buffer between the road and the creek.	Filter Strip Practice #240 (active management) Erosion Control Fabric, Practice #331 (mild engineering) Road Stabilization, Practice #470 (moderate engineering) Silt Fence, Practice #333 (mild engineering)

Identified Nonpoint Sources	General Recommended BMPs	Specific BMP Practices (See Appendix E)
Sowers Canyon Creek (main tributary to Antelope Creek)		
Streambank erosion	Develop off-stream livestock watering facilities stations and fencing to reduce streambank trampling. Stabilize eroding streambanks with engineered structures such as log abutments, willow fascines, and grade stabilization structures. Revegetate eroding streambank areas with woody vegetation.	Fencing, Practice #220 (active management) Pole/Post Plantings, Practice #260 (active management) Brush Layer, Practice #301, Brush Mattress Practice #302, Brush Revetment, Practice #303, Brush Trench, Practice #330, & Willow Fascines, Practice #305 (mild engineering) Erosion Control Fabric, Practice #331 (mild engineering) Seeding, Practice #221 (active management) Fiberschines/Biologs, Practice #332 (mild engineering) Grade Stabilization Structure, Practice #420 (moderate engineering) Vertical Bundle, Practice #304 (mild engineering)
Oil and gas development	Oil and gas developments are required to transport produced water to an approved disposal facility. There have been occurrences of illicit dumping in the past and with the recent growth in drilling activity there is an apparent need for additional education and enforcement.	Silt Fence, Practice #333 (mild engineering) Straw Roll/Bale Barrier, Practice #334 (mild engineering)
Antelope Creek (confluence with Duchesne River to headwaters)		
Irrigated pasture and hayland	Establish and maintain vegetation buffer strips. Improve irrigation water management through development of site-specific conservation plans. Increase irrigation efficiency through the use of sprinkler or gated pipe irrigation to reduce deep percolation. Reduce canal seepage by lining canals.	Filter Strip, Practice #240 (active management) Silt Fence, Practice #333 (mild engineering) Irrigation Sprinklers, Practice #452 (moderate engineering) Irrigation Pipeline, Practice #450 (moderate engineering) Irrigation System, Drip, Practice #451 and Surface #453 (moderate engineering)
Oil and gas development	Oil and gas developments are required to transport produced water to an approved disposal facility. There have been occurrences of illicit dumping in the past and with the recent growth in drilling activity there is an apparent need for additional education and enforcement.	Silt Fence, Practice #333 (mild engineering) Straw Roll/Bale Barrier, Practice #334 (mild engineering)

Identified Nonpoint Sources	General Recommended BMPs	Specific BMP Practices (See Appendix E)
Lake Fork River (confluence with Duchesne River to Pigeon Water Creek confluence)		
Irrigated pasture and hayland	Establish and maintain vegetation buffer strips. Improve irrigation water management through development of site-specific conservation plans. Increase irrigation efficiency through the use of sprinkler or gated pipe irrigation to reduce deep percolation. Reduce canal seepage by lining canals.	Filter Strip, Practice #240 (active management) Silt Fence, Practice #333 (mild engineering) Irrigation Water Management Practice #140 (passive management) Irrigation Sprinklers, Practice #452 (moderate engineering) Irrigation Pipeline, Practice #450 (moderate engineering) Irrigation System, Drip, Practice #451 and Surface #453 (moderate engineering)
Pastureland	Implement rest-rotation grazing systems. Revegetate streambanks with woody vegetation and/or allow for re-establishment.	Grazing Management, Practice #120 (passive management) Seeding, Practices #221 & Pole/Post Plantings #260 (active management) Exotic Removal Practice #210 (active management) Constructed Wetland, Practice #500 (intense engineering) Watering Facility, Practice #370 (mild engineering)
Oil and gas development	Oil and gas developments are required to transport produced water to an approved disposal facility. There have been occurrences of illicit dumping in the past and with the recent growth in drilling activity there is an apparent need for additional education and enforcement.	Silt Fence, Practice #333 (mild engineering) Straw Roll/Bale Barrier, Practice #334 (mild engineering)
Duchesne River (confluence Green River to Randlett)		
Irrigated pasture and hayland	Establish and maintain vegetation buffer strips. Improve irrigation water management through development of site-specific conservation plans. Increase irrigation efficiency through the use of sprinkler or gated pipe irrigation to reduce deep percolation. Reduce canal seepage by lining canals.	Filter Strip, Practice #240 Silt Fence, Practice #333 (mild engineering) Irrigation Water Management Practice #140 (passive management) Irrigation Sprinklers, Practice #452 (moderate engineering) Irrigation Pipeline, Practice #450 (moderate engineering) Irrigation System, Drip, Practice #451 and Surface #453 (moderate engineering)

Identified Nonpoint Sources	General Recommended BMPs	Specific BMP Practices (See Appendix E)
Duchesne River (confluence Randlett to Myton)		
Irrigated pasture and hayland	Establish and maintain vegetation buffer strips. Improve irrigation water management through development of site-specific conservation plans. Increase irrigation efficiency through the use of sprinkler or gated pipe irrigation to reduce deep percolation. Reduce canal seepage by lining canals.	Filter Strip, Practice #240 Silt Fence, Practice #333 (mild engineering) Irrigation Water Management Practice #140 (passive management) Irrigation Sprinklers, Practice #452 (moderate engineering) Irrigation Pipeline, Practice #450 (moderate engineering) Irrigation System, Drip, Practice #451 and Surface #453 (moderate engineering)
Pasturelands	Implement rest-rotation grazing systems. Revegetate streambanks with woody vegetation and/or allow for re-establishment.	Grazing Management, Practice #120 (passive management) Seeding, Practices #221, Pole/Post Plantings #260, Exotic Removal Practice #210 and Fencing #220 (active management) Constructed Wetland, Practice #500 (intense engineering) Watering Facility, Practice #370 (mild engineering)
Open drainage canals	For canal seepages, line canals with concrete to control/limit infiltration losses.	Irrigation Pipeline, Practice #450 (moderate engineering)
Streambank erosion	Develop off-stream livestock watering facilities stations and fencing to reduce streambank trampling. Stabilize eroding streambanks with engineered structures such as log abutments, willow fascines, and grade stabilization structures. Revegetate eroding streambank areas with woody vegetation.	Fencing, Practice #220 (active management) Pole/Post Plantings, Practice #260 Seeding, Practice #221 (active management) Brush Layer, Practice #301, Brush Mattress Practice #302, Brush Revetment, Practice #303, Brush, Trench, Practice # 330 & Willow Fascines, Practice #305 (mild engineering) Erosion Control Fabric, Practice #331 (mild engineering) Fiberschines/Biologs, Practice #332 (mild engineering) Grade Stabilization Structure, Practice #420 (moderate engineering) Vertical Bundle, Practice #304 (mild engineering)

9.2 Schedule

It is important to realize that TMDL implementation activities can take many years to achieve meaningful and lasting pollutant reductions and improved water quality conditions. The preceding implementation strategies and recommendations are focused to achieve improvements in overall water quality throughout the entire Duchesne River watershed. Although some activities might result in relatively rapid water quality improvements, most activities will require a long time to show measurable results.

The implementation of these TMDLs will rely on a long-term approach. The time frame for implementation is estimated to be at least 15 years (Table 9-2). The time frame estimated for improving water quality is 5 to 15 years, depending on several variables. Factors that could affect the speed of the implementation include both human factors and natural conditions. Much of the schedule is dependent upon the level of effort and time required to solicit cooperators and funding partners to implement the recommended BMPs. Once BMPs are installed, the natural conditions and variability of the ecosystem will also play a part in determining the timeframe for achieving water quality standards.

Table 9-2. Proposed schedule of Duchesne River watershed TMDL implementation activities

Implementation Action	Implementation Year Number														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Public outreach and involvement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Establish milestones	X					X					X				
Public education & involvement	X	X	X	X	X										
Demonstration projects	X	X	X	X	X										
Secure project funding	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Implement BMPs	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Determine BMPs effectiveness				X					X						X
Reevaluate milestones/strategies					X					X					

10. FUTURE MONITORING

Continued water quality monitoring is essential to evaluate the effects of BMPs, as well as progress toward meeting water quality goals and supporting beneficial uses. Continued monitoring will allow for the periodic reevaluation of the implementation strategies, milestones, and goals defined in this TMDL document.

The results of these TMDLs can provide a basis for future data collection and implementation of some of the actions and management measures required to implement the allocations provided in this report. Further data should be collected and the TMDLs should be refined, as appropriate, based on the results of additional analysis. As new data become available through monitoring efforts, elements of the TMDL may be changed to reflect this new information.

Implementation of projects directed toward reducing TDS loading should continue while new data are being collected. Issues such as water rights, instream flows, and restrictions on land application will also need to be considered during development of specific projects. A monitoring program is critical to understanding the ultimate impact of BMP implementation on TDS concentrations in the Duchesne River watershed.

In addition to regular water quality monitoring, upland and riparian areas should be monitored periodically. The purpose for monitoring these areas is to identify where the significant sources of sediment and salt originate in the watershed.

The following are additional topics or sources of information that would help to enhance these TMDLs in the future:

- Efforts should be made to sample the volume and characteristics of irrigation return flows to better estimate their impact on instream water quality.
- Photo monitoring sites can be used for future comparisons of changes in geomorphology, streambanks, riparian conditions, flow levels, and salt crusts.
- Aerial photo analysis can be used to monitor the riparian corridor health, the composition of the vegetation in the riparian corridor, the amount of invasive Tamarix and to track geomorphic changes over time.
- Permanent follow-up monitoring sites can be selected depending on the location of future implementation projects and sampled to establish simple trend analysis and gauge BMP effectiveness.
- Any detailed water quality information (specifically for TDS/salinity/chlorides), stream flow, irrigation diversions, and land use information from the Ute Tribe for the Duchesne River watershed would be helpful in refining the TMDLs.
- Any current monitoring and/or assessment information from Upper Colorado River Endangered Fish Recovery Program on the impacts of water development projects on endemic fish species of the Upper Colorado River system including the Duchesne River and its tributaries should be reviewed.

- Current updates from the Utah Salinity Workgroup Task Force Meetings that may affect activities in the Duchesne River watershed should be considered.

- Information on any local watershed planning efforts currently taking place in the watershed should be considered during implementation.

- Intense oil and gas exploration development (including coal bed methane) are expected within the Uintah Basin over the 15-year planning period of the proposed BLM Resource Management Plan (RMP). Because oil and gas drilling could be a water quality issue in the basin, more detailed information on the location and the potential for new oil, gas, and coal bed methane wells will be important.

- Information on active diversions in the watershed would be useful, so that, if necessary, information on water withdrawal records can be queried from the Utah Division of Water Rights.

- The U.S. Fish and Wildlife Service (USFWS) identified the Duchesne River as having significant benefits to endangered species. The lower 2.5 miles of the Duchesne River has been designated as critical habitat for the razorback sucker. Any information on current or future coordination efforts with the USFWS for this project will be important.

11. FUTURE ACTIVITIES IN THE WATERSHED

This section describes future activities planned in the Duchesne River watershed that could positively or negatively affect TDS loadings in the future. These activities should be considered when planning implementation activities and for any future updates to the Duchesne River watershed TMDLs. These activities may also better indicate natural TDS conditions in the watershed and isolate specific areas or potential future sources of TDS loadings.

11.1 The Colorado River Basin Salinity Control Program

Under the NRCS Environmental Quality Incentives Program (EQIP), six resource concerns were identified as priorities for FY 2006. EQIP provides cost share and incentive payments to implement conservation practices on eligible agricultural lands. One of the priority areas identified by the NRCS is the Colorado River Basin Salinity Control Program (CRBSCP).

A major resource concern addressed by EQIP is salt loading to the Colorado River drainage. The CRBSCP receives funding ($40 million in 2005) that is earmarked for salinity control on irrigated lands. This money is available to producers with irrigated lands in a designated portion of Uintah and Duchesne County (as well as other counties). Monies are designated at the national level, and are used to improve irrigation efficiency and wildlife habitat to replace habitat loss as a result of the improved irrigation projects. This program is lead by the Bureau of Land Management, the NRCS, and the CRBSCF, through State Agriculture Departments, and the Soil Conservation Districts. EQIP has “earmarked” 2.5 percent for continued support for the CRBSCP as a national priority. In 2004, approved Utah’s portion of the CRBSCP funds totaled $9,959,457.

The CRBSCF Workgroup met several times in 2005 and is preparing a new report on the economic damages associated with high salinity concentrations and the continued need for salinity control programs.

11.1.1 Basinwide Salinity Control Programs

Federal salinity programs of the BOR and NRCS in the Uintah Basin are expected to continue. The goal of the program is to reduce salt loads from the Uintah Basin by an additional 34,500 tons/year by 2020 through the construction of additional salinity offset projects. The BOR is nearing completion of 15 projects and is negotiating 10 new project agreements (CUP, 2003).

Riverdell Water Systems Improvement

The BOR expects complete water systems improvements on the Riverdell property in the Duchesne River watershed in the near future. The BOR is rehabilitating the water delivery system by replacing the Riverdell Canal with a new diversion on the Duchesne River and an enclosed pipeline for more than half the existing canal length. Deep percolation of water from canal systems is a major source of salinity in the river and is a major emphasis for salinity reduction in the BOR Basinwide Salinity Control Project (CUP, 2003).

11.1.2 Bureau of Land Management Salinity Reduction Program

A basinwide status report on BLM salinity control programs is due to Congress in the near future. When this report is completed, a salinity control target will be established that should help the BLM reduce the baseline salinity in the Uintah Basin (CUP, 2003).

11.2 Section 203(a) Uintah Basin Replacement Project

This proposed water project would change water storage, enlarge an existing reservoir, stabilize 13 high mountain lakes, and would add new water diversion and distribution facilities for irrigation and municipal water use. This project would also provide water for instream flows on certain portions of the Lake Fork River. Flow inputs from Lake Fork River to the Duchesne River would be reduced by 3,345 acre feet (4 percent of the annual flow), possibly increasing 242 ppm of TDS in the Lake Fork River (URMCC, 2003).

A proposed modification is also being made by the Utah Reclamation Mitigation and Conservation Commission (URMCC) to an existing agreement with the Ute Tribe. This modification would obligate additional funds for continued planning and National Environmental Policy Act (NEPA) analysis for the Lower Duchesne River Wetlands Mitigation Project in FY2006.

11.3 Upper Colorado Endangered Fish Recovery Program

In 2004, the Ute Tribe Fish and Wildlife Department developed a comprehensive plan to manage fish species that are native to the Uintah and Ouray Indian Reservation. This plan was developed between the Ute Tribe Fish and Wildlife Department, and the USFWS. On the reservation, there are several species that have been identified as needing special management because of threats to their populations and the deterioration of their habitats (Ute Tribe, 2005). The USFWS has recommended instream flows for the Duchesne River; however, the flows have not been implemented, and the future nature of these flows cannot be predicted (URMCC, 2003).

11.4 Future Oil and Gas Developments in the Duchesne River Watershed

According to the BLM's *Mineral Potential Report for the Vernal Planning Area* (2002), there is high and moderate potential for the occurrence of oil and gas resources in the Vernal Planning Area (Figure 11-1). This planning area includes the Duchesne River watershed. There will be continued exploration and development of these resources within the next 15 years.

There is high and moderate occurrence potential for oil and shale within the Vernal Planning Area. It is expected that one or two small-scale projects may be active for oil shale over the next 15 years. Also, there is moderate potential for the occurrence of economical coal deposits within the Vernal Planning Area. It is unlikely that coal exploration or development will occur over the next 15 years.

According to this 2002 BLM report, significant oil and gas activity is expected to occur on federal acreage in the Vernal Planning Area over the next 15 years. This oil and gas activity is projected to include some coal-bed methane exploration and development as well. Approximately 2,055 oil wells, 4,345 gas wells, and 130 coal bed methane wells are anticipated to be developed over the planning period.

Surface disturbance related to oil and gas development in each of the designated development areas is expected to occur. A total of 84 new compressor sites, each with an average surface disturbance of 2 acres per site, are anticipated to accommodate projected new oil and gas wells in the Vernal Planning Area (BLM, 2002).

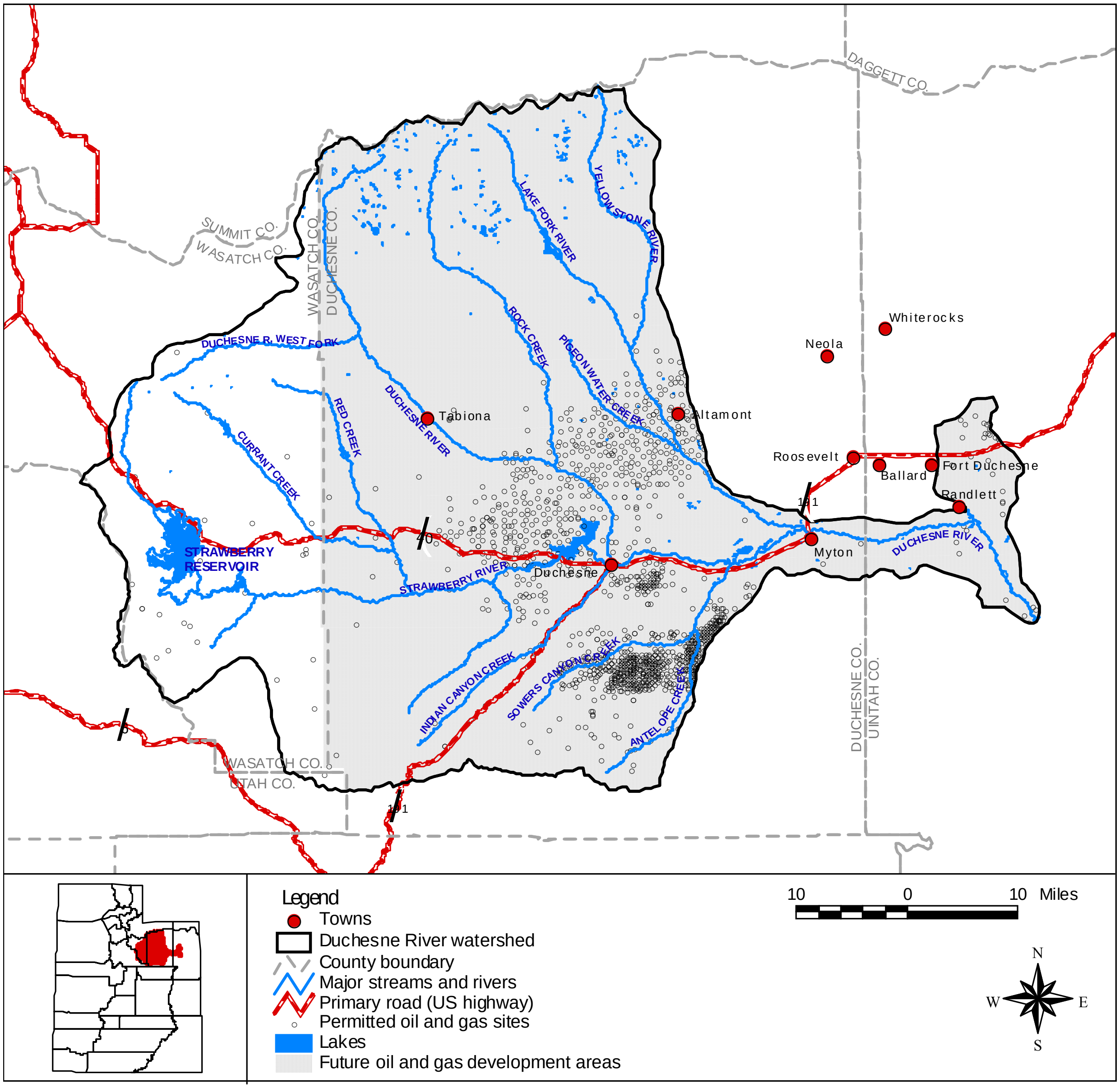

Figure 11-1. Current and potential oil and gas development areas

11.5 BLM-Vernal Field Office Draft Environmental Impact Statement

The BLM-Vernal Field Office (VFO) has issued a draft Environmental Impact Statement (EIS) for the VFO RMP (BLM, 2005). This RMP integrates the Book Cliffs and Diamond Mountain RMPs into a single new RMP. The VFO RMP will provide planning guidance for public land and federal mineral estate management by the VFO in Daggett, Duchesne, and Uintah Counties in northeastern Utah, as well as a small portion of Grand County. The BLM manages approximately 30 percent of the land within the planning area. The VFO RMP analyzes four alternative proposals for managing public lands focusing on development opportunities and protection of natural resources. Resources within the planning area include mineral resources, wildlife, fisheries, vegetation, rangeland, wild horses, wilderness, cultural resources, water resources, wetlands and riparian resources, visual and recreational resources. Land uses and economic resources include oil and gas, phosphate, tar sands, Gilsonite, livestock grazing, woodland products, building stone, and rights-of-way.

The VFO conducted studies to project oil and gas development activities within the planning area. For the purposes of this report, the oil and gas projections within the Duchesne River watershed are important developments that may impact the TDS loading to the Duchesne River. Oil and gas potential within the Duchesne River watershed are characterized as moderate to high production potential. Figure 10-2 shows the projected oil and gas development for the VFO planning area in the Duchesne River watershed. Presently, the surface disturbance for oil and gas activities occurring in the VFO RMP study area total 5,667 acres for short-term disturbance, and 19,738 acres for the life of the activity. Activities related to oil and gas development include access roads; pipeline gathering and transportation systems; power lines; well pad construction; service and production wells; and plugged and abandoned wells.

The preferred alternative (Alternative A) describes management activities as providing a generally broad management direction to accommodate a wide variety of values and uses. The planning area would be managed to provide development opportunities while protecting sensitive resources. This alternative employs timing and sequencing of events through adaptive management on the basis of sensitive resource indicators

The comment period for the VFO RMP draft EIS was scheduled to close on June 24, 2005. Comments were received and are being reviewed internally (J. Kenczka, BLM-VFO, personal communication, October 19, 2005). Anticipated publication of a final EIS is expected in late summer or early fall of 2006. No decisions have been made regarding the implementation of the VFO RMP.

11.6 USFWS Mountain Prairie-Region, Baseflow Recommendations for Duchesne River

The USFWS established baseflow conditions for the Duchesne River to support native fish populations in USFWS (2003). The objective of the recommendation is to maintain passage needs and a level of biological activity necessary to sustain the aquatic productivity and prey base of Colorado pikeminnow. Implementation of flow recommendations to primarily benefit Colorado pikeminnow and the aquatic productivity in the Duchesne River will also benefit razorback sucker and associated critical habitat in the Green River by providing and maintaining habitat in the lowermost portions of the Duchesne River and contributing flows that help inundate floodplains in the Green River below the Duchesne River. This plan will restore riverine habitat for threatened and endangered species by delivering flood flows to move sediment and create backwaters for fish, which could conflict with the TDS TMDLs for the Duchesne River watershed recommending stabilizing streambanks and preventing erosion.

Baseflow recommendations were made utilizing the existing data from the USGS Randlett gauge. The gauge was moved in 2004 due to difficulties sustaining a rated cross section, channel configuration and icing. The change in physical conditions surrounding the gauge might have affected the flow measurements. The USFWS suggests completing a comparative evaluation of the flows at the new location with the previous location. If the flows from the new location do not track with the existing record, the flow recommendations will be reassessed.

12. LOCAL STAKEHOLDER AND PUBLIC PARTICIPATION

Local stakeholder participation for these draft TMDLs was accomplished through stakeholder meetings in 2005. The first Duchesne River watershed TMDL meeting was held at the Fort Duchesne Ute Tribal Fish and Wildlife offices on June 1, 2005. This meeting was designed to present and review the data summary report and discuss the water quality study design. The second stakeholder meeting was also held at the Fort Duchesne Ute Tribal Fish and Wildlife offices on September 21, 2005, to review the source assessment work, status of the data summary report, and discuss TMDL milestone dates. The third stakeholder meeting was held on December 1, 2005 to present the draft TMDLs.

Participants in the three meetings included:

- Duchesne County Water Conservancy District
- Northern Ute Tribe, Water Quality Division
- Northern Ute Tribe, Fish and Wildlife Division
- Northern Ute Tribe, Wetlands Division
- NRCS
- River Commissioner for Uinta and Whiterocks Rivers
- River Commissioner for Duchesne and Strawberry Rivers
- USFS, Ashley National Forest
- UDEQ, Division of Water Quality
- Utah Association of Conservation Districts
- Utah State Senate
- Utah State University Extension

It is important to have local input to affect water quality improvements and practices. Local irrigation companies and shareholders involved in agricultural production are already actively participating in the CRBSCP to reduce salt loading in the watershed through improved irrigation practices. This proven program has and will continue to help reduce salt loading into the Duchesne River watershed and Colorado River systems.

The draft TMDL report was available for public review and comment from November 21, 2005, through December 21, 2005. Public notices were published in the *Uintah Basin Standard*, *Salt Lake Tribune*, and *Deseret Morning News* and the public meeting to present the draft TMDLs was held on December 1, 2005, at the Utah State University Extension Center in Roosevelt, Utah. In addition, representatives from UDEQ, Ute Tribe and Duchesne County Water Conservancy District met on December 13, 2005, to discuss comments on the draft TMDL report.

REFERENCES

Ayers, R.S., and D.W. Westcot. 1994. *Water quality for agriculture*. FAO Irrigation and Drainage Paper 29, Revision 1. Reprinted 1989, 1994. Food and Agriculture Organization of the United Nations, Rome, Italy.

BLM (Bureau of Land Management). 2005. *Draft Resource Management Plan and Draft Environmental Impact Statement for the Bureau of Land Management's Vernal Field Office*. Vernal, Utah.

BLM (Bureau of Land Management). 2002. *Mineral Potential Report for the Vernal Planning Area*. Bureau of Land Management, Vernal Field Office, Vernal, Utah.

BOR (Bureau of Reclamation) and NRCS (Natural Resources Conservation Service). 1993. *Price-San Rafael Rivers Unit, Utah: Planning Report/Environmental Impact Statement*. Salt Lake City, UT.

CUP (Central Utah Project). 2003. *Salinity Impact Analysis, Uinta and Ouray Lower Duchesne River Wetland Enhancement Plan*. Prepared for the Ute Indian Tribe and Western Wetland Systems, Provo, Utah.

CRSCF (Colorado River Salinity Control Forum). 2005. *2005 Review, Water Quality Standards for Salinity, Colorado River System*. Colorado River Salinity Control Forum, Bountiful, Utah.

CCREM (Canadian Council of Resource and Environment Ministers). 1987. *Canadian water quality guidelines*. Prepared by the Task Force on Water Quality Guidelines.

Moon, D. 1997. *Memorandum on Use Attainability Analysis and Ambient Based Criteria*. U.S. Environmental Protection Agency Region 8, Ecosystem Protection and Remediation office, Denver Colorado.

NAS (National Academy of Sciences) and NAE (National Academy of Engineering). 1973. *Water quality criteria 1972*. U. S. Environmental Protection Agency, Ecological Research Series Report R3-73-033, Washington, DC.

UDEQ (Utah Department of Environmental Quality). 2005. *Uintah Basin Watershed Description*. Utah Department of Environmental Quality, Division of Water Resources, www.utah.gov. Accessed September 2005.

UDEQ (Utah Department of Environmental Quality). 2004a. *Utah's 2004 303(d) List of Impaired Waters*. Utah Department of Environmental Quality, Division of Water Quality, Salt Lake City, Utah. April 1, 2004. (http://www.waterquality.utah.gov/documents/2004303dlistFINALall-11-04-04.pdf)

UDEQ (Utah Department of Environmental Quality). 2004b. *TMDL Water Quality Study of the Virgin River Watershed*. Prepared by Tetra Tech, Inc. January 2004. (http://www.waterquality.utah.gov/TMDL/lower%20colorado%20final%20draft%20TMDL.pdf)

URMCC (Utah Reclamation Mitigation and Conservation Commission). 2003. *Draft Lower Duchesne River Wetlands Mitigation Project, EIS*. Prepared for the Ute Indian Tribe, Utah.

USFWS (U.S. Fish and Wildlife Service). 2003. *Flow Recommendations for the Duchesne River with a Synopsis of Information Regarding Endangered Fishes.* U.S. Fish and Wildlife Service, Colorado River Fish Project, Vernal, Utah.

USFWS (U.S. Fish and Wildlife Service, Region 6). 2004. *Update of the Reasonable and Prudent Alternative in the July 1998 Biological Opinion for the Duchesne River Basin.* U.S. Fish and Wildlife Service, Utah.

Utah State University. 2002. *Sprinklers, Crop Water Use, and Irrigation Time*. ENGR/BIE/WM/28. Utah State University Extension. March 2002.

Wischmeier, W.H., and D.D. Smith. 1978. *Predicting Rainfall Erosion Losses - A Guide to Conservation Planning.* USDA Handbook 537. Washington, DC: U.S. GPO.

APPENDIX A: SUMMARY OF EXISTING REPORTS AND ACTIVITIES

Table A-1 summarizes the reports collected and reviewed for characterization of the Duchesne River watershed. The following pages summarize existing studies, reports, and activities within the Duchesne River watershed (and the surrounding area) that can affect TDS concentrations and address such topics as irrigation practices, salinity control projects, and surface and ground water quality. The sources of these reports range from government agencies to nonprofit associations. The purpose of this compendium of information is to augment the TMDL report with information regarding current conditions and projected changes in the watershed. Each report and activity listed in Table A-1 is summarized in this appendix.

Table A-1. Existing reports and information on the Duchesne River watershed

Document Title/Website	Date	Author
Draft Resource Management Plan and Draft Environmental Impact Statement for the Bureau of Land Management's Vernal Field Office (VFO RMP-Draft EIS)	January 2005	BLM-VFO (Utah)
Draft: Salinity Impact Analysis: Uinta and Ouray Lower Duchesne River Wetland Enhancement Plan; Prepared for the Ute Indian Tribe and Western Wetland Systems	July 2003	Central Utah Project (CUP)
2005 Review Water Quality Standards for Salinity Colorado River System DRAFT	June 2005	CRBSCF
Executive Director's Monthly Report to the Colorado River Board of California for February 8, 2005; http://www.crb.ca.gov/2005Feb08_ED.pdf	February 8, 2005	Colorado River Board of California
Executive Director's Monthly Report to the Colorado River Board of California for August 23, 2005; http://www.crb.ca.gov/2005Aug23_ED.pdf	August 23, 2005	Colorado River Board of California
Upper Colorado River Endangered Fish Recovery Program (News Release)	April 5, 2005	USFWS
Update of the Reasonable and Prudent Alternative in the July 1998 Biological Opinion for the Duchesne River Basin	May 4, 2005	USFWS
Flow Recommendations for the Duchesne River with a Synopsis of Information Regarding Endangered Fishes	September 2003	USFWS (Utah) and Central Utah Water Conservancy District
Field Screening of Water Quality, Bottom Sediment, and Biota Associated with Irrigation on the Uintah and Ouray Indian Reservation, Eastern Utah, 1995; Water-Resources Investigations Report 98-4161	1998	USGS
Colorado Connection Newsletter; http://www.co.nrcs.usda.gov	July/August 2005	NRCS
Conservation Issues 2005; Excerpt: Colorado Salinity Control Program; http://www.uacd.org/pdf/conservation_issues_2005.pdf.	March 21, 2005	Utah Association of Conservation Districts
Utah Nonpoint Source Pollution Management Plan; Excerpt: Colorado River Salinity Control Program	October 2000	UDEQ
Commission Meeting Agenda for Thursday, September 29, 2005; http://www.mitigationcommission.gov/news/mtg_agenda.html	September 29, 2005	URMCC
Draft Environmental Impact Statement for the Lower Duchesne River Wetlands Mitigation Project	November 2003	URMCC
Ute Tribe Fish and Wildlife Department Homepage; http://www.utetribe.com	2005	Ute Tribe (Utah)

BLM-VFO (Utah); *Draft Resource Management Plan and Draft Environmental Impact Statement for the Bureau of Land Management's Vernal Field Office*; January 2005.
The VFO of the Utah BLM has initiated the revision and combination of the Book Cliffs and Diamond Mountain RMPs into one RMP. This RMP "will provide planning guidance for public land and federal mineral estate managed by the VFO in Daggett, Duchesne, and Uintah Counties in northeastern Utah, as well as a small portion of Grand County…. The Diamond Mountain portion of the planning area includes BLM-administered lands and minerals in Daggett and Duchesne Counties (S-1)." Under the National Environmental Policy Act of 1970, the BLM-VFO is required to conduct an analysis of the potential environmental impacts resulting from implementing changes to management plans. (See Figure 10-1 for a map of existing oil and gas permitted sites in the Duchesne watershed). Below is an excerpt from the VFO RMP-Draft EIS describing the four management alternatives considered (S-3).

> **Alternative A:** This alternative provides generally broad management direction to accommodate a wide variety of values and uses. The planning area would be managed to provide development opportunities while protecting sensitive resources. This alternative employs timing and sequencing of events through adaptive management based on sensitive resource indicators. It designates 10 ACECs and recommends sections of two rivers for Wild and Scenic River designation. The two sections of rivers include the White River from the state line to ten miles downstream of Asphalt Wash and the upper and lower Green River. It has more area available for oil and gas leasing than Alternative D (No Action).
>
> **Alternative B:** This alternative focuses on providing development and use opportunities, while addressing required natural resource protection through focused and prudent mitigation measures. It designates seven ACECs and recommends sections of one river for Wild and Scenic River designation. This alternative has the largest area open to oil and gas leasing.
>
> **Alternative C:** This alternative focuses on protection of natural and cultural resources, while providing compatible development and use. It designates 14 ACECs and recommends sections of 6 rivers and creeks for Wild and Scenic River designations. It has the least amount of area open to oil and gas leasing.
>
> **Alternative D:** This alternative would maintain present uses by continuing present management direction as stipulated in the Diamond Mountain and Book Cliffs RMPs. This alternative would also comply with all new mandates, Executive Orders and directives that have been implemented since these previous RMPs were compiled. This alternative had the greatest amount of unregulated open area for off-highway vehicle (OHV) use and no designated OHV routes. It designates seven ACECs and recommends sections of one river for Wild and Scenic River designation.

The projected oil and gas development may impact TDS loadings into streams and tributaries within the Duchesne watershed. Previous to this EIS analysis, the VFO completed a projection of mineral development for the foreseeable future (*Mineral Potential Report*; BLM- VFO; 2004). The baseline information determined that there are 1,536,030 acres available for oil and gas development. Figure 10-1 shows the existing oil and gas permitted sites in the Duchesne watershed. Six development areas were identified and evaluated: (1) Altamont-Bluebell; (2) East Tavaputs Plateau; (3) Manila-Clay Basin; (4) Monument Butte-Red Wash; (5) Tabiona-Ashley Valley; and (6) West Tavaputs Plateau. Four of the development areas overlap the Duchesne River watershed. From north to south these development areas include the Tabiona-Ashley Valley, Monument Butte-Red Wash, Altamont-Bluebell, and West Tavaputs Plateau. Of these four development areas, the largest areas of overlap are Monument Butte-Red Wash and Altamont-Bluebell (Table A-2).

Table A-2. Projected Oil and Gas Development Within Reasonably Foreseeable Development Areas in the Duchesne River Watershed

Development Area	Projected Oil and Gas Development	Anticipated Surface Disturbance (miles/acres)	
		Short Term	Life of Activity
Tabiona-Ashley Valley	30	5/35	12/99
Monument Butte- Red Wash	4,800	720/5,584	1766/15,615
Altamont-Bluebell	425	64/495	157/1,382
West Tavaputs Plateau	425	72/552	176/1,547

Presently, the surface disturbance for oil and gas activities occurring in the VFO RMP study area total 608 miles (5,667 acres) for short-term disturbance, and 1,725 miles (19,738 acres) for the life of the activity. Activities related to oil and gas development include access roads, pipeline gathering and transportation systems; power lines; well pad construction; service and production wells; and plugged and abandoned wells. Table A-3 details the projected oil and gas development for each alternative and potential impact to surface conditions. *Italics* indicates the preferred alternative identified in the VFO RMP-Draft EIS.

Table A-3. Projected Increases in Oil and Gas Wells in the Duchesne River Watershed

Alternative	Oil and Gas Wells	Acreage for Leasing and Potential Development of Oil and Gas Wells
Alternative A	+1.5%	+14.0%
Alternative B	+2.2%	+18.0%
Alternative C	-0.4%	+6.0%
Alternative D	0	0

NOTE: The comment period for the VFO RMP Draft EIS was scheduled to close on June 24, 2005. Comments were received and are being reviewed internally (J. Kenczka, BLM- VFO, personal communication, October 19, 2005). Anticipated publication of a Final EIS is expected in late summer/early fall 2006.

CUP; Swanson, R.G., *Draft: Salinity Impact Analysis: Uinta and Ouray Lower Duchesne River Wetland Enhancement Plan*; Prepared for the Ute Indian Tribe and Western Wetland Systems; July 2003.

This analysis evaluated the potential for salinity loading that may occur in the Duchesne River watershed and Colorado River system from implementation of the Uinta and Ouray Lower Duchesne River Wetlands Enhancement Project (LDWP). The LDWP is being planned and implemented in partial fulfillment of mitigation obligations arising from the construction and operation of the Bonneville Unit of the CUP that has affected Ute Indian Tribal resources along the Duchesne River.

In the early 1980s, the BOR developed a water quality (hydrosalinity) model known as the Colorado River Simulation System to evaluate the impacts of water project developments and salinity control. Salinity in the Colorado River has fluctuated significantly due to highly variable flows over the period of hydrologic record (about 1941-1999). Salinity concentrations generally decrease in periods of high flow and increase in periods of low flow. In 1986, the BOR conducted canal seepage studies on 25 Uintah Basin main canals and additional laterals totaling over 800 miles.

The Duchesne River watershed drains an active agricultural area characterized by moderate- to high-salinity soils and is, therefore, an important contributor of salinity to the rest of the Colorado River system. Salinity has long been recognized as one of the major problems in the Colorado River system. The Colorado River has excellent water quality with a salinity concentration of 50 mg/L at its headwaters in northwest Colorado. This concentration progressively increases downstream as a result of water diversions and salt contributed from a variety of sources. Natural (historical) salinity in the lower Colorado River Basin has been estimated at 334 mg/L. Nearly half (47 percent) of the salinity in the entire Colorado River system is from natural sources, including saline springs, erosion of saline geologic formations (Uinta, Duchesne River and Mancos Formations) and rainfall runoff. Many saline sediments within the basin originate from prehistoric marine shale formations that were deposited when vast oceans covered the Colorado River Basin. Salts contained within sedimentary rocks laid down under these inland seas are easily eroded, dissolved, and transported into the river system. Irrigation, reservoir evaporation, and municipal and industrial sources and other human activities make up the balance of salinity (53 percent) in the entire system and of this amount, irrigation accounts for 37 percent. Federally developed irrigation projects are the largest user of water in the Duchesne River watershed and a major contributor of salinity to the system. Irrigation increases salinity by reducing the volume of water through plant uptake and by deep percolation, which dissolves salts found in underlying saline soils. Irrigation delivers this salt-laden water to basin streams via groundwater recharge and field drains.

Uintah Basin Salinity

The salinity in source water for the Uintah Basin is low, with TDS ranging from 30 to 350 mg/L. As water leaves the basin, the TDS concentrations increase from 200–4000 mg/L. The average value is 680 mg/L. These concentrations were calculated using long-term records from 1941 to 1980. Typically, the TDS of water is less than 300 mg/L during irrigation season. Concentrations sometimes reach 800 mg/L late in the irrigation season when significant portions of the total river flow are composed of irrigation return flow.

Salinity loading data have been developed by the NRCS. The BOR uses this data to help evaluate the feasibility of salinity offset projects under the Basinwide Salinity Control Project. Data are in tons per acre-foot (acre-ft) of deep percolation water. Table A-4 shows a wide disparity in salinity loading data throughout the basin due to varying geologic conditions.

Table A-4. Uintah Basin Loading Data

Uintah Basin Area	Salinity (tons/acre-ft)
White Rocks	3.19
Brush Creek	3.28
Dry Gulch	2.92
Pelican Lake	1.99
Arcadia	2.22
Ashley Valley	1.57
Lake Fork	0.75
Upper Duchesne	0.56
Lower Duchesne	2.58
Fruitland/Strawberry	0.70
Tabiona/Hanna	0.46
Green River/Jensen	2.35
Price River	5.01
San Raphael River	3.65

The LDWP is considered to be in the lower Duchesne River watershed. According to the salinity loading data, the natural environment contributes 2.58 tons of salinity annually for each acre-ft of water applied to the land. A generally accepted average of 450,000 tons of salt is contributed to the Colorado River from the Uintah Basin each year. Of this annual average, the estimated long term average salt contribution from the Duchesne River is 330,000 tons per year. A few other saline tributaries, including Ashley Creek, make up the difference. Irrigation return flows from 204,000 acres of irrigated lands within the basin account for most of the anthropogenic salt loading in the Duchesne River. Soils in the project area are considered to be moderately to strongly saline, capable of producing high salinity loads in the river with deep percolation. The LDWP project area is largely, if not totally, within the area indicated as strongly saline. For comparison, Table A-5 provides general information on potential water use restrictions due to salinity.

Table A-5. Guidelines for Interpretation of Salinity Impacts

Impact Issue	Degree of Impact (None)	Degree of Impact (slight to moderate)	Degree of Impact (severe)
Irrigation water	<450	450 to 2,000	>2,000
Waterfowl ducklings	<3,200	>3,200	Unknown
Riparian plants (soil salinity)	<2,000	>2,000	Unknown
Trout waters			>2,000
Non-trout waters			>5,000
Metro water district southern California	<500		

In 2002, the CRBSCF established a target for basinwide salinity reductions of 1.8 million tons/yr. Salinity control measures in place as of 2001 have controlled about 800,300 tons/yr to date. The current goal is for reduction/control of an additional 1 million tons/yr by 2020. Full implementation of the plan is intended to offset the salinity impacts from human activities from 1972 to 2020 in the Colorado River Basin. The BOR and NRCS operate the Basinwide Salinity Control Program in Uintah and Duchesne Counties. The program's objective is to reduce salt loading to the Duchesne River and the Colorado River system. The program operates within the CRBSCF and provides technical support and funding to line or replace existing canals in an effort to eliminate seepage and improve the efficiency of on-farm irrigation by conversion to sprinkler systems.

As of 2001, salt reduction measures in place for the Uintah Basin are controlling an estimated 106,000 tons/yr. New measures are planned to control an additional 34,500 tons/yr. Table A-6 defines baseline conditions for salinity loading assuming that 51.2 percent of groundwater returns to the Duchesne River as subsurface flow and the remaining 48.8 percent of water is consumed by wetlands and phreatophytic vegetation. Baseline conditions are broken into specific geographic locations specified to address local salinity loading.

Table A-6. Definition of Baseline Conditions—estimate baseline salinity contributions

Project Area	Size (acres)	Irrigated Acres	Irrigation (acre-ft/yr)	Deep Percolation[1] (acre-ft/yr)	Salinity Factor (tons/ acre-ft)	Salinity Loading (tons/ acre-ft)
Flume	1,597	905.91	5,526	3,715	2.58	4,907
Uresk Drain	1,916	917.19	4,849	3,014	2.58	3,982
Riverdell (North)	1,087	565.5	0	0	2.58	0
Riverdell (South)	1,054	568.87	3,003	1,865	2.58	2,464
Ted's Flat	2,073	671.32	2,980	1,638	2.58	2,163
Total	**7,727**	**3,628.79**	**16,358**	**10,232**	2.58	**13,516**

[1]Deep percolation includes canal losses, percolation from cropped fields, and surface infiltration of water. These are considered the main routes of salinity loading.

For deep percolation, the net consumptive use of water by crops is estimated at 2.0 acre-ft per acre of irrigated crops. Consumptive use reduces the irrigation supply available for deep percolation, and therefore reduces the potential for salinity loading. Specific mitigation measures to reduce salinity impacts should focus on reducing the seepage rate. Measures could include reducing the size of wetlands, lining newly constructed ponds with impermeable soils or artificial membranes to completely reduce seepage, and implementing a seasonal program of pond operations that would result in draining the ponds for a period of time each year. Salinity impacts would be reduced in proportion to the time the ponds are drained.

In 1986, the BOR estimated that lining 55 miles of canals and laterals in the Uintah Basin would result in a reduction of 2.3 mg/L (TDS) at Imperial Dam or a 1 mg/L reduction for each 11,086 tons/yr. The BOR posits that a change of 10,000 tons of salt is required to change salinity by 1 mg/L at Imperial Dam. Wetland and phreatophyte consumptive use has been estimated at 2.7 acre-ft per acre in the Uintah Basin.

Federal salinity control programs of the BOR and NRCS in the Uintah Basin are expected to continue. The Basinwide Salinity Control Project goal is to reduce Uintah Basin baseline salt loads by an additional 34,500 tons/yr by 2020 through construction of additional salinity offset projects. The BOR is nearing completion of 15 approved projects and is negotiating 10 new project agreements for proposals received in 2001.

Bureau of Land Management Salinity Reduction Program

A basinwide status report on BLM salinity control programs is due to Congress in the near future. When this report is completed, a salinity control target will be established that should assist the BLM to reduce baseline salinity in the Uintah Basin.

The BOR expects to complete water system improvements on the Riverdell property in the near future. Improvements include rehabilitation of the water delivery system by replacing the Riverdell Canal with a new diversion on the Duchesne River and an enclosed delivery pipeline for more than half the existing canal length. Deep percolation of water from canal systems is a major source of salinity in the river. Thus, addressing deep percolation is a major emphasis for salinity reduction in the BOR Basinwide Salinity Control Project. The BOR estimates that typical unlined canals in the Uintah Basin, such as Riverdell, will suffer seepage losses of up to 30 percent. Salinity is declining in the river and in the basin.

Note: As of this report, efforts to follow up on the Congressional report on the basinwide status of BLM salinity control programs were unsuccessful.

CRBSCF; *2005 Review Water Quality Standards for Salinity Colorado River System DRAFT*; June 2005.
Section 303 of the Clean Water Act requires that water quality standards be reviewed from time to time, but at least once during each 3-year period. In general, over the last 30 years, the salinity concentrations have decreased at all three of the numeric criteria stations established by the CRBSCF. The numeric criteria stations are below Hoover Dam, at Imperial Dam, and below Parker Dam. In 1970, the concentrations of all three stations were at or above the numeric criteria for those stations. The present conditions indicate that concentrations at these locations are well below the numeric criteria. Upwards of 1 million tons of salt load per year have been reduced due to the implementation of the salinity control program. The salinity control program has resulted in concentrations being lower at the numeric criteria stations by as much as 100 mg/L. Utah's portion of the Colorado River Basin is composed of nine major sections, including the Duchesne River watershed.

Colorado River Board of California; *Executive Director's Monthly Report to the Colorado River Board of California for February 8, 2005*; February 8, 2005; http://www.crb.ca.gov/2005Feb08_ED.pdf
The CRBSCF Workgroup held a meeting in Salt Lake City, Utah, on January 12–13, 2005. A summary of the EQIP Financial Assistance Obligations and Technical Assistance Expenditures that have been allocated to approved Colorado River Basin Salinity Control projects for 2004 in Utah totaled $9,959,457.00, which represents 51 percent of the total funds awarded to Colorado, Utah and Wyoming.

Colorado River Board of California; *Executive Director's Monthly Report to the Colorado River Board of California for August 23, 2005*; August 23, 2005; http://www.crb.ca.gov/2005Aug23_ED.pdf
The CRBSCF Workgroup held a meeting in Cortez, Colorado, on July 19–21, 2005. The workgroup intends to prepare a report to the Forum focusing on the economic damages associated with high salinity concentrations and the need for salinity control programs.

USFWS; Upper Colorado River Endangered Fish Recovery Program News Release; *Experimental Management of Northern Pike and Smallmouth Bass Continues in Utah and Colorado*; April 5, 2005.
The Upper Colorado River Endangered Fish Recovery Program continues to employ management strategies to control the populations of northern pike and smallmouth bass in certain river reaches where scientific evidence shows that these non-native species threaten the survival of the endangered humpback chub, bonytail chub, Colorado pikeminnow, and razorback sucker. This program is a collaborative effort among the Utah Division of Wildlife Resources, the Colorado Division of Wildlife, the USFWS and biologists from Colorado State University. From April to October 2005, a concerted effort will be made to remove the nonnative species from river sections, including the Duchesne River. In addition to northern pike and smallmouth bass, channel catfish also pose a serious threat to endangered Colorado fisheries. Recovery Program efforts include providing adequate river flows, restoration of habitat, construction of fish ladders and screens, production and distribution of endangered fish and monitoring results. This program was established in 1988 and continues to be a voluntary program to recover endangered fish while water development proceeds in accordance with federal and state laws and interstate compacts.

USFWS; Mountain Prairie-Region; *Update of the Reasonable and Prudent Alternative in the July 1998 Biological Opinion for the Duchesne River Basin*; May 4, 2005.
The 1998 Duchesne Biological Opinion determined that historic operations and the development of new water projects in the Duchesne River watershed continued to endanger the listed fishes and was likely to jeopardize the continued existence of native fishes and their habitat in the Duchesne, Green and Colorado Rivers. Several mitigating actions were identified in the Reasonable and Prudent Alternative (RPA), including follow-up studies to evaluate flow recommendations for the Duchesne River. This Biological

Opinion provides a summary of new information on the biology and habitat requirements of the Colorado pikeminnow and razorback sucker and final flow recommendations for flows to support these species. It also provides a new RPA that updates and replaces the original RPA.

According to some studies, the baseflow recommendations for maintenance of native fish populations in the Duchesne River focus on passage needs and maintenance of a level of biological productivity necessary to sustain aquatic productivity and prey base. Flows of 115 cubic feet per second (cfs) in the Duchesne River provide optimum thalweg depths, allowing for the passage of all but the largest fish. Baseflows to sustain stream productivity should not drop below 50 cfs. Passage flow recommendations were made for the period between March 1 and June 30 when Colorado pikeminnow utilize the river most heavily. The flows are based on the 25-year period of record at the Randlett gauge (1975-2000). Implementation of flow recommendations designated primarily to benefit Colorado pikeminnow and the aquatic productivity in the Duchesne River also will benefit razorback sucker and associated critical habitat in the Green River by providing and maintaining habitat in the lowermost portions of the Duchesne River and contributing flows that help inundate floodplains in the Green River below the Duchesne River.

The USFWS evaluates fish recovery progress separately for the Colorado River and the Green River sub-basins. However, it gives due consideration to the progress made on listed species recovery throughout the Upper Colorado River Basin in evaluating progress toward recovery. The USFWS has determined that if all cooperating and partnering agencies implement the recommendations identified in this RPA, these actions may reduce the likelihood of jeopardizing the continued existence of endangered fishes and avoid destruction or adverse modification of critical habitats for all Federal projects identified in the 1998 Duchesne Biological Opinion. Significant progress was made implementing the previous RPA, particularly in the areas of research and preparatory work for implementing on-the-ground actions. This amended RPA includes items carried over from the initial RPA as well as new tasks.

In 2004, the USGS gauge at Randlett was moved due to difficulties in maintaining a rated cross section, channel configuration and icing. The change in physical conditions surrounding the gauge might have affected the flow measurements. The USFWS suggests completing a comparative evaluation of the flows at the new location with the previous location. If the flows from the new location do not track with the existing record, the flow recommendations will need to be reassessed.

USFWS- Colorado River Fish Project (Vernal); Modde, T. (USFWS) and C. Keleher, Central Utah Water Conservancy District; *Flow Recommendations for the Duchesne River with a Synopsis of Information Regarding Endangered Fishes: Draft Final Report Submitted to the Upper Colorado River Basin Endangered Fishes Recovery Implementation Program, Project No. 84-1*; September 2003.

The Duchesne River is a highly modified river system that has been influenced by both natural precipitation patterns and intense water development. Flow recommendations for the Duchesne River represent an integration of physical processes needed to maintain channel complexity and substrate quality (high flow needs), with maintenance of adequate flows needed for endangered fish access, and productivity needed to sustain the prey base support Colorado pikeminnow (base flow needs).

The average annual yield of the Duchesne River measured at the Randlett gauge is estimated to be 768,000 acre-feet. During the period of record from 1970 to 1990, depletions from both private and federal sources have reduced annual yield by an estimated 54–74 percent. The dramatic reduction in flows has contributed to morphological changes in the Duchesne River, which has affected habitat use and availability for fish. Current use by endangered fishes suggests that the Duchesne River continues to be a resource to Colorado pikeminnow and razorback sucker. In recognition of this resource, the lower 2.5 miles of the Duchesne River was designated as critical habitat for razorback sucker in 1994. Flow recommendations proposed were compared with present water use patterns to determine the extent in which hydrological limitation affect recovery potential within the Duchesne River. The deficit between the recommendation and available water represents the target for future acquisition opportunities.

Field surveys were conducted between 1997 and 2000 to assess the fish populations, habitat ranges, and age range of resident fishes in the Green, Yampa, White, and Duchesne Rivers. Among the tributaries to the Green River, the Yampa and White Rivers represent a significant resource to the Colorado pikeminnow. Telemetry data in 2003 provided strong evidence that most pikeminnow only use the Duchesne River during the spring and summer months. Colorado pikeminnow displayed a pattern of movement into and out of the Duchesne River, entering the tributary in early spring and leaving between late spring and fall. Failure to use the Duchesne River during the winter base flow period may be a response to the periodic occurrence of extremely low base flows that have occurred in the last 60 years. Razorback sucker use only the lower reaches of the Duchesne River, specifically the area influenced by water elevation of the Green River. Razorback sucker have been observed in tributary mouths and floodplain outflows in the spring, especially following spawning in late May and June. Outside of the areas influenced by the Green River, razorback sucker do not appear to be common in tributaries of the Green River subbasin. It is likely that if razorback sucker were more abundant in the Green River subbasin, fish would probably be collected more frequently in smaller tributaries. However, it is unlikely that the Duchesne River upstream of critical habitat would contribute significantly to the recovery of razorback sucker in the Green River subbasin.

The goal of the following flow recommendations are to maintain the existing level of habitat availability and endangered fish use as presently exists in the Duchesne River. These recommendations address the reach of the Duchesne River downstream from the confluence with the Uinta River. Base flow recommendations are based on Colorado pikeminnow passage requirements (March 1- June 30) and maintenance of a minimum level of instream productivity to support a prey base for the Colorado pikeminnow for the remainder of the year. The base flow recommendation target a minimum flow of 115 cubic feet per second (cfs) between March 1 and June 30 to ensure fish access and passage. During the remainder of the year, the base flow recommendation is for a minimum flow of between 50 cfs to 155 cfs to ensure adequate prey populations for the Colorado pikeminnow. During wet years, flows should not fall below 115 cfs. During normal to dry years, flows between June 30 and February 28 should not fall below 115 cfs at a frequency greater than that observed in the last 25 year period of record, and every effort should be made to maintain flows above 50 cfs at all times. Base flow recommendations for this report were developed from information collected primarily downstream of the Randlett gauge on the Duchesne River and should be measured at the Randlett or other comparable gauge. Instream flows for the Duchesne River upstream of the Randlett gauge were not specifically quantified. However, due to the documented occurrence of the Colorado pikeminnow upstream in the Duchesne River, and the importance of upstream areas to prey fish production, it is recommended that a significant portion of the water delivered to the target reach (below Randlett) be delivered from the Duchesne River above the confluence with the Uinta River to provide some level of minimum flows in the Duchesne River between Myton and the Randlett gauge for fish passage and biological productivity in that stream section.

Guidelines relative to instream productivity determined from other studies were applied to riffle-area/discharge relationships in the Duchesne River to determine base flow needs. Similarly, the minimum flow recommendations are based on minimum production estimates that were developed on riffle-area/discharge relationships from other streams and not specifically determined for the Duchesne River. The base flow recommendations represent flows that have been determined to provide adequate production in other western streams and rivers. It is recommended that fish population and habitat parameters be periodically monitored in the Duchesne River to ensure their adequacy. It is further recommended that the USFWS establish a workgroup consisting of state and local stakeholders that will meet as necessary to discuss and make recommendations for implementation of flow recommendations.

USGS; Stephens, D. (USGS) and B. Waddell (USFWS); *Field Screening of Water Quality, Bottom Sediment, and Biota Associated with Irrigation on the Uintah and Ouray Indian Reservation, Eastern Utah, 1995*; Water-Resources Investigations Report 98-4161; Salt Lake City, Utah; 1998.
This report contains the results of a 1995 field-screening study of the physical, chemical and biological conditions associated with water developed as part of the Uintah Indian Irrigation Project of the Bureau of Indian Affairs (BIA), the CUP, and the Central Utah Project Completion Act. The field screening of water quality, bottom sediment, and biota was conducted by the USGS at selected sites on the Uintah and Ouray Indian Reservation of eastern Utah. The purpose of this evaluation was to determine if irrigation or project mitigation water delivered by the U.S. Department of Interior caused adverse effects on fish and wildlife resources or on human health. TDS concentrations in the water from 40 percent of the sites exceeded the State agricultural standard of 1,200 mg/L. High TDS concentrations could adversely affect some agricultural crops, but is not hazardous to waterbirds.

The Uintah and Ouray Indian Reservation covers about 4,000,000 acres of trust land, fee land, private land, USFS land and BOR land along the Green River in north central Utah. The Reservation is divided into a northern segment centered on the Duchesne River, and a southern segment extending downstream to the Book Cliffs. Virtually all the population, water resources, and irrigation activities are in the northern segment, specifically the Duchesne River watershed. The southern segment is rugged, high country with few inhabitants, and a small amount of irrigation east of the Green River, mostly along the White River. There about 60,000 acres of Indian irrigation lands receiving 3–4 acre-ft of project water per acre.

About 38,500 acres of non-Indian agricultural lands within the confines of the reservation receive supplemental CUP water. The principal water source for the area is snowmelt runoff transported by streams on the southern slope of the Uinta Mountains, namely the Uinta River, Whiterocks River, Yellowstone River, Lake Fork River, and Strawberry River. The Duchesne River is the largest receiving stream and discharges to the Green River. Strawberry Reservoir (35 miles west of Duchesne River) and Starvation Reservoir are the most important impoundments constructed by the CUP. Smaller projects and private reservoirs that are on or adjacent to reservation lands include, Lake Borham (also called Midview Reservoir), Big Sand Wash, Twin Pots, Montez Creek, Bottle Hollow, Cedar View, and Brough Reservoirs. Water in the reservoirs is used for municipal, agricultural and wildlife purposes.

An extensive system of private and rehabilitated canals exist throughout the Duchesne River watershed. The geology of the reservation is varied, but most of the formations include the Uinta Formation, Green River Formation, and Duchesne River formation, all of which are considered "seleniferous in areas." Source areas for the streams on the southern border of the Duchesne River watershed, specifically Antelope and Indian Canyon Creeks, are underlain by the Green River Formation. The Green River flows through the reservation and is designated as critical habitat for four species of endangered fish—razorback sucker, humpback chub, bonytail chub, and Colorado pike minnow. Bald eagles use the area during the winter. All rivers, ponds, reservoirs, and canals are used by waterbirds for feeding and nesting. The Green River is a principal migration corridor for the Pacific flyway. The USFWS leases a small part of the Ouray National Wildlife Refuge from the Ute tribe.

Field studies revealed an upland area 1 mile southeast of Myton along the Myton townsite canal contained 5 ug/L of selenium in irrigation drainwater and a farm pond near Pelican Lake contained 4 ug/L of selenium. Data from an earlier study of irrigation water quality in Pariette wetlands showed selenium concentrations as high as 7 ug/L. Concentrations of selenium in pied billed grebe eggs and carp were as high as 16.9 ug/g dry weight.

During 1994, the USGS in cooperation with Central Utah Conservancy District collected and analyzed surface water and bottom sediment samples at 14 sites in the Duchesne River watershed as part of the CUP. Generally, the water quality was excellent and contamination at lower elevation sites was minimal. In general, concentrations of dissolved solids increased substantially downstream. Several samples of water from the Lake Fork River near Myton contained dissolved solids concentrations that exceeded the Utah agricultural protection standard of 1,200 mg/L. Three samples from the Duchesne River at Randlett exceeded the standard for dissolved solids. Four samples from the Uinta River at Randlett exceeded the dissolved solids standard.

Presently, the Uintah Indian Irrigation Project of the BIA provides a maximum water allocation of 3 acre-feet per acre from March 1 to November 1 of each year for about 16,000 acres. Water is distributed from the Lake Fork, Uinta, and Whiterocks Rivers. Long-term development of water on Indian and non-Indian lands throughout the Uintah Basin mostly has been a result of the CUP, a water development plan designed to permit Utah to use a substantial portion of its allotted share of Colorado River water. The Ute Indian Unit was planned to provide water for Indian and non-Indian lands but was not funded by Congress.

The last unit is the Bonneville Unit, which involves a trans-basin diversion of water from the Uintah Basin to the Wasatch Front. To acquire water from the Ute Tribe, the BOR and the BIA, Ute Tribe, and CUWCD entered into the Ute Indian Deferral Agreement of 1965, wherein the tribe agreed to defer development of 15,242 acres of irrigable land and provide the water for the Bonneville Unit. In return, the non-Indian parties recognized Indian water rights to 36,450 acres by the Duchesne River and the U.S. Government agreed to develop substitute water resources and distribution facilities for the Ute Tribe by January 1, 2005.

In 1980, the Utah State legislature approved a Ute Indian Water Compact, intended to resolve present and future controversies concerning the amount, distribution, and use of waters claimed by the tribe. The Compact is awaiting ratification by all parties. The Compact provides for a depletion of 248,943 acre-ft annually and a related diversion of 471,035 acre-ft for all uses. The Ute Tribe also has a water right to an annual depletion of 10,000 acre-ft for municipal and industrial uses. The total acreage under or planned for irrigation with Indian-owned water is 129,201 acres, less 7 percent to reflect nonproductive uses such as roads and rights of way. The Compact was revised in 1990. The Ute Tribe receives a share of the Bonneville Unit revenues, a development fund, to aid in improvement of farming operations. Bonneville Unit revenues also provide economic opportunities on the reservation and other benefits designed to improve natural resources, such as stream improvement and removal of contaminants from Bottle Hollow Reservoir.

In general, 20 water sampling sites were chosen to determine trace element concentrations in irrigation return flows and drainwater (if any) entering and leaving reservation lands or reservoirs. Eleven sites were selected to determine if contamination was present in six wildlife mitigation areas owned by the Ute Tribe along the Duchesne River. Water samples were collected in June or early July and again in late August when irrigation and returns are at a maximum. Overall, the water is hard, with dissolved solids concentration ranging from 109 mg/L to 3,620 mg/L. Water from 40 percent of the sites had at least one sample that exceeded the State agricultural standard of 1,200 mg/L for TDS, and 30 percent of the sites had water samples that exceeded the standard on two collection dates.

Concentrations of TDS were high in water from several sites on the Uintah and Ouray Reservation, particularly where agricultural return flows discharge to the Duchesne River. High concentrations of dissolved salts, occasional high water temperatures during summer and widely fluctuating concentrations of dissolved oxygen may limit the types of aquatic species and their growth and reproduction in some areas of the Uintah and Ouray Reservation.

Note: Efforts to access information regarding the ongoing project to remove contaminants from Bottle Hollow Reservoir were unsuccessful in locating a report. Inquiries were made to USGS, USFWS and the BOR.

U.S. Department of Agriculture, NRCS; *The Colorado Connection Newsletter*; July/August 2005; http://www.co.nrcs.usda.gov
The CRBSCF and Workgroup hosted a quarterly meeting in Cortez, Colorado, July 20 to 22, 2005. The Workgroup recommends to the agencies how to distribute state funds for salinity control projects. Funds totaled $40 million in 2005. The BLM builds off-farm projects and the NRCS, with the assistance of the conservation districts, builds on-farm irrigation improvement projects.

***Conservation Issues 2005* (report submitted to Utah's Congressional Delegation); Excerpt: Colorado Salinity Control Program; March 21, 2005; http://www.uacd.org/pdf/conservation_issues_2005.pdf.**
The issue being reviewed is the continued allocation of a 2.5 percent Congressional appropriation. The program continues to be identified as a National Priority under NRCS's EQIP and policies affecting the program. Several upper Colorado River Basin states have received additional funding for salinity control in designated salinity control areas. This program currently removes 772,627 tons of salt per year reducing the TDS of the river in the lower basin by 65 mg/L, saving downstream users over $88 million in treatment costs. Utah has over 127,000 more acres that could be treated, resulting in further reduction of salinity load to the river. In addition, improved irrigation efficiency has saved over 87,600 acre-feet of water per year and has simultaneously improved agricultural production.

UDEQ in cooperation with the Utah Nonpoint Source Task Force; *Utah Nonpoint Source Pollution Management Plan*; Excerpt: Colorado River Salinity Control Program; October 2000.
Salinity enters the Colorado River system through groundwater and as sediment transported through streams. The Colorado River Basin contains many saline bearing geologic formations. Some of the higher saline geologic units found in the Colorado River Basin include Mancos Shale, Carmel, Tropic Shale, and Green River formations. These salt-laden rock units weather into soil that can then become sediment through the processes of wind and water erosion. It has been determined that for every ton of salt delivered, or for every 33.3 tons of sediment delivered to the stream, there is 1 ton of salt delivered to the system.

The UDEQ has established a TMDLs program to determine the amount of a pollutant or stressor that a waterbody can sustain and still meet its beneficial uses. In addressing pollutants (i.e., TDS, salinity, nutrients, organics, etc.), effective TMDLs identify both point and nonpoint sources contributing to the load. Through Section 319 funding of the Clean Water Act, the UDEQ provides technical assistance and funding to implement management strategies aimed at reducing pollutant loads such as erosion control, salinity reduction, irrigation management, watershed restoration, habitat alteration, and wetlands improvements.

URMCC; *Commission Meeting Agenda for Thursday, September 29, 2005*; September 29, 2005; http://www.mitigationcommission.gov/news/mtg_agenda.html
Agenda Item #3D. A proposed modification was made to an existing agreement with the Ute Indian Tribe to obligate additional funds for continued planning and NEPA analysis for the Lower Duchesne River Wetlands Mitigation Project in FY2006. NOTE: Subsequent visits to the Web site did not reveal meeting minutes or indicate the action of the Commission with respect to this agenda item.

URMCC; *Draft Environmental Impact Statement for the Lower Duchesne River Wetlands Mitigation Project*; November 2003.

The LDWP responds to the need to mitigate for past impacts of the SACS on portions of Strawberry Reservoir and the Duchesne River, downstream of Starvation Reservoir. Flows diverted from the Duchesne River resulted in a loss of wetlands, riparian habitat, and wetland associated wildlife along the Duchesne River from Duchesne to Ouray. Most of the impacts occurred to land within the Uinta and Ouray Indian Reservation. Three action alternatives were considered to restore wetlands and riparian habitat and associated tribal benefits along the Duchesne River. Each alternative addresses the obligation to provide mitigation for the impacts of SACS on wetlands adjacent to the Duchesne River and to provide additional wetland-wildlife benefits to the tribe. The alternatives combine fee lands and tribal trust lands to be placed under a conservation easement to be managed in conjunction with the Duchesne River Area Canal Rehabilitation Project, resulting in a project area of 7,727 acres

The CUP was authorized in 1956 as part of the Colorado River Storage Project Act. The Bonneville Unit is the most expensive and complex subunit of the CUP and delivers water from the Uintah Basin to the Wasatch Front. One completed feature of the Bonneville Unit is the SACS, an aqueduct system that gathers water from the upper Duchesne River and various tributaries. Water is transported to Strawberry Reservoir for storage and use on the Wasatch Front. As a result of SACS, wetland-wildlife habitat was lost along the Duchesne River and adjacent to Strawberry Reservoir. Most of these losses occurred on tribal lands. Under full operation, the Bonneville Unit is expected to deliver approx 102,000 acre-feet of water to the Wasatch Front on an average annual basis.

In 1995, the Mitigation Commission provided the tribe with the necessary funding to initiate planning for the LDWP. Rehabilitation measures include rewatering oxbows, connecting oxbows to their 1936 widths, enhancing water quality in areas receiving agricultural return flows, filling drainage ditches to create large marsh complexes, replanting riparian areas with native woody trees and shrubs, seeding of new wetland edges, removing non-native invasive species, and changing management of areas adjacent to wetlands to benefit wildlife. There are four oxbow systems within the entire project area that historically formed annually flooded, continuous side channels of the Duchesne River. Where feasible, oxbows would be connected to the river. The river has narrowed up to 40 percent, has been downcut by 2 to 4 feet, and had its flow reduced by diversions. Large marshes would be created on the Uresk Drain Site by filling some drainage ditches and constructing a series of berms to retain and pond water on the site. Woody riparian vegetation will be planted on former Duchesne River floodplains and non-native and invasive woody species such as tamarisk and Russian olive will be removed.

Controversial aspects of this project include a loss of 21,000 acres of private property lowering the local tax base, increased wetlands and marshy habitats, known breeding sites for mosquitoes, and the loss of cattle grazing on 6,212 acres. Seven endangered species are known to occur in the study area. They are the Uinta Basin hookless cactus, Ute ladies' tresses orchid, Colorado pike minnow, razorback sucker, bald eagle, mountain plover, and western yellow billed cuckoo.

All the irrigable land within the project area, except the Riverdell North property, are supplied by 1861 Indian Water Rights and are authorized for direct diversion from the Duchesne River. These water rights total 17,802 to 20,653 acre-feet. There are no anticipated changes in water deliveries.

TDS and boron have been identified as the most problematic contaminants in the study area. Return flows from irrigated lands increase the level of these contaminants. To combat this problem, wetlands would be operated as flow-through systems, with extra water delivered to each site to prevent accumulation of salts and to maintain acceptable water quality levels. This supplemental water would be provided from canals with low levels of boron and TDS, such as the Myton Townsite Canal or the Duchesne River.

Project Area History

Major irrigation canals to divert water locally from the river were constructed between 1907 and 1920. By 1940 much of the floodplain had been converted to cropland. Two major canals along the lower river, the Grey Mountain canal and Myton Townsite canal, currently divert an average annual total of 81,145 acre-feet. Other local irrigation diversions along the river divert an additional 56,000 acre-ft. Trans-basin diversions began in 1915 with the Strawberry Valley Project. Other trans-basin diversions have been added, including diversions from the North Fork of the Duchesne River to the Provo River in 1953. The largest and most recent diversion began in 1967 as a result of the CUP. From 1943 to 1990, total flow depletions averaged 43 percent of the natural flows; the flow depletions have increased from 1973 to 1990, averaging 51 percent of total runoff. After the implementation of Stillwater Reservoir in 1987, flow depletions have averaged 79 percent, with a high of 85 percent in 1990.

The proposed action affects four sites ranging from Flume, Uresk Drain, Riverdell North/South, and Ted's Flat sites. Flume begins at an active secondary channel 4.5 miles west of Myton and 0.75 miles north of Highway 40. Uresk Drain starts north of Colorado Road 8000 S, which borders the southern edge of Myton. Riverdale North/South consists of 2,190 acres, bordered by the Uresk Drain site, along River Road. Ted's Flat consists of 2,073 acres and encompasses both sides of the river from the Ouray School Canal to Myton Townsite.

Interrelated Projects

Colorado River Salinity Control Program

The program reduces salt loading to the Duchesne River and eventually the Green and Colorado Rivers through rehabilitating existing canals and improving the efficiency of on-farm irrigation systems.

Mallards Spring Mitigation Plan

Mallard Springs Wildlife Management Area is a 270-acre parcel owned by the state. The Duchesne County Water Conservancy District developed 38 acres of open water wetlands as mitigation for impacts under the Colorado River Salinity Program.

Duchesne River Area Canal Rehabilitation Mitigation

The USFWS purchased the Riverdell North property in 1982 to conduct Duchesne River Area Canal Rehabilitation mitigation. The program replaced 390 wetland-wildlife habitat units through creation, restoration, and enhancement of 450 acres of wetland.

Riverdell North Property Water System Improvement Project

This project consists of 1,087 acres of land owned by the government primarily on the north side of the Duchesne River east of Myton. The property was acquired for mitigation of wetland losses resulting from the Duchesne River Area Canal Rehabilitation Project.

Section 203(a) Uintah Basin Replacement Project

The proposed water project that would change water storage, enlarge an existing reservoir, stabilize 13 high mountain lakes, add new water diversion and distribution facilities for irrigation and municipal water use, and provide water for instream flows on certain portions of the Lake Fork River. The project area includes the Duchesne River downstream of Myton. Input from Lake Fork River to the Duchesne River would be reduced by 3,345 acre-feet (4 percent of the annual flow), with an increase of 242 ppm of TDS in the Lake Fork River.

Upper Colorado Endangered Fish Recovery Program

This is an interagency project to recover the endangered Colorado pikeminnow, razorback sucker, humpback chub, and bonytail chub, while still allowing for resource development. The USFWS recommended instream flows for the Duchesne River; but the flows have not been implemented, and the future nature of these flows cannot be predicted. Program objectives include monitoring population trends and habitat development such as restoring floodplain habitats. Targeted species include channel catfish, smallmouth bass, mountain whitefish, carp, bluehead sucker, and Utah chub.

Duchesne River Flows

The Duchesne River flows through deposits of clay, silt, sand and gravel that are generally less than 15 feet thick. The valley contains numerous off-channel depressions and oxbow lakes that mark former positions of the river. In all but a few cases, these oxbows and off-channel depressions are no longer directly connected to the river; rather, they are supported primarily by irrigation return flows or local groundwater discharge. The main geologic formation is the Uintah Formation, characterized as a calcareous shale with some beds of limestone, claystone, siltstone, and sandstone. The Uintah Formation grades upwards to the Duchesne River formation. The beds of the upper Uintah Formation and the lower Duchesne River Formation form a common aquifer that is one of seven known groundwater aquifers within the Uintah Basin. The uppermost aquifer consists of shallow, unconsolidated gravels of Quaternary age adjacent to and underlying the major stream valleys. The general direction of flow is to the south and towards the Duchesne River channel.

Since 1989, discharge of the river has averaged 168,142 acre-feet at the Myton gage and 258,361 at the Randlett gage. The Myton gage is 3 miles downstream of the Lake Fork River and 1 mile downstream of the U.S. Highway 40 bridge in Myton. The Randlett gage is 0.25 miles downstream of the confluence with the Uinta River and 1.2 miles southeast of Randlett. The average streamflow for the respective gages are 232 cfs at Myton and 357 cfs at Randlett. At the Myton gage, 64 percent of annual discharge occurs during the irrigation season (April 1 through October 31) and 43 percent of annual discharge occurs from May 1 through July 31 during spring runoff. At Randlett, 66 percent of annual discharge occurs during the irrigation season and 45 percent occurs during spring runoff. Since 1989, the average date of the spring discharge peak has been June 7 at both gage sites.

The Myton gage records streamflow from flows in the Duchesne River and Lake Fork River, and return flows from lands irrigated by the Duchesne Feeder, Grey Mountain, Myton Townsite, Pahcease, Midview, and Dry Gulch Canals. Flows on Lake Fork have not been gaged since 1981. In most years Lake Fork is dewatered in late summer below the Pahcease Canal inlet and only irrigation return flows enter the river during irrigation season. Flows at the Randlett gage include irrigation return flows between Myton and Randlett and inflows from the Uintah River.

There are eight major canal systems in the lower Duchesne River that deliver water within the Uintah Basin. Two of these canals, Grey Mountain Canal and Duchesne Feeder Canal, have diversion points 3.0 miles and 3.9 miles, respectively, west of the project area boundary. These two canals are responsible for almost 78 percent of the local diversions, with annual diversion averaging 113,000 acre-feet. The Grey Mountain Canal and the Uintah Basin Irrigation Company Canal run jointly for the initial eight miles. Grey Mountain canal traverses the southern boundary of the project area between Bridgeland and Myton and supplies water to South Myton Bench and Pleasant Valley. The Duchesne Feeder Canal supplies water to Midview Reservoir and Moon Lake Canal. Since 1989, approximately 19,074 acre-feet of water is diverted annually by the Myton Townsite Canal. The Riverdell Canal diverted an average of 447 acre-feet and Ouray School Canal diverted 10,516 acre-feet. Most of the water diverted is to irrigate pasture lands. The average flow return is 51.1 percent. For the period 1989-2002, water diversions from canals within the project area have averaged 52,287 acre-ft per year and have ranged from 45,353 to 60,317 acre-ft per year. Water diversions have varied between less than 12 percent and greater than 20 percent of average. Table A-7 reviews the amount of water delivered from major canals within the LDWP area.

Table A-7. Major Canals Delivering Water within the LDWP Area and Average Diversion Amounts for the Period of 1989 to 2002 (following the closure of Stillwater Reservoir)

Canal	Diversion Point	Average Diversion (acre-feet)	Diversion Ranges (acre-feet)
Uintah and Ouray Irrigation Project			
Grey Mt	2.5 miles west of Bridgerland	22,697	19,873–26,306
Myton Townsite	2 miles west of Myton	19,074	16,703–21,436
Ouray School	3.5 miles west of Duchesne–Uintah Co. Line	10,516	8,777–12,575
Total Uintah and Ouray Irrigation Projects		52,287	43,353–60,317
Other Canals			
Riverdell	1.5 miles west of Duchesne–Uintah Co. line	447	0–2,029

Water Availability

There are between 17,802 and 20,635 acre-feet of water rights associated with land in the project area, depending on the alternative. Although all the lands in the project area are mixed ownership, all the water rights in the project area (except those for the Riverdell North property) are senior Indian water rights with an 1861 priority date. Indian water rights are the most senior water rights on the Duchesne River. The water rights associated with the Riverdell North property are junior water rights with a 1916 certification date. Water from the Duchesne River is delivered on a priority basis to senior water rights holders over junior water rights holders. On average, 52,287 acre-ft of water are diverted from canals within the LDWP project area operated by the Uintah and Ouray Irrigation Project, with an additional 2,267 acre-ft of water rights associated with the Riverdell North Property. Overall, water diversions have varied by +/- 10 percent of the average of 52,287 acre feet per year, while streamflow during the same period has ranged from –80 to +200 percent of average. Under baseline conditions, not all parcels within the project area irrigate according to their full water right every year, with some lands remaining fallow in any given year.

TDS concentrations in the project area are generally above the wildlife standards, but are well below the toxic effects levels. The USFWS identified that none of the levels of the constituents would be limiting to adult waterfowl. Sampling sites in which the highest concentrations of TDS were observed, also were sites with the lowest flows. High TDS concentrations in the Riverdell North/South oxbows were measured at discharges of 0.01 cfs or less.

Population Trends

From 1990 to 2001, the population of Duchesne County grew from 12,600 to 14,646, an annual increase of 1.5 percent. During the same period, the population of Uintah County grew at nearly an identical rate of 1.6 percent from 22,230 to 26,049. Both counties experienced population growth rates below the statewide average of 2.9 percent during the 1990s. Tribal members make up 15.4 percent of the total population within the Uintah and Ouray Indian Reservation. There are 3,205 members of the tribe, most of who live on the reservation. The low population of tribal members on tribal lands is due to the location of the five most populous cities in the Uintah Basin within the reservation boundaries. The tribal population has remained relatively constant over the past decade. There are no projections available for future population growth rates on the reservation. Most of the tribal land used for agricultural purposes within the project area is leased to non-tribal members for either grazing or crop production. Either the tribe or individual allottees receive lease payments for the land but do not receive a royalty on the production.

Ute Tribe (Utah); Ute Tribe Fish and Wildlife Department Homepage; 2005; www.utetribe.com

In 2004, the Ute Tribe Fish and Wildlife Department developed a comprehensive plan to manage fish species that are native to the Uintah and Ouray Indian Reservation. The plan was developed between the

Ute Tribe Fish and Wildlife Department and the USFWS. On the reservation, there are several species that have been identified as needing special management strategies due to threats to the population and the deterioration of suitable habitats. Some species are federally recognized as endangered or threatened and by the state of Utah as species of special concern. The Ute Tribe's Native Fish Planning and Implementation Project consists of a few related objectives. The primary objective is to develop and implement a management plan for the fish species that are native to the Uintah and Ouray Indian Reservation. The second objective is to develop and implement management prescriptions to maintain and/or restore damaged native fish habitat. The Ute Tribe Fish and Wildlife Department and the USFWS will monitor the recovery progress of the federally listed endangered and threatened fish species that occupy the Uintah and Ouray Indian Reservation.

APPENDIX B: NLCD LAND COVER DESCRIPTION

Water—All areas of open water or permanent ice/snow cover.

11. Open Water—All areas of open water, generally with less than 25 percent cover of vegetation/land cover.

12. Perennial Ice/Snow—All areas characterized by year-long surface cover of ice and/or snow.

Developed- Areas characterized by a high percentage (30 percent or greater) of constructed materials (e.g., asphalt, concrete, buildings, etc).

21. Low Intensity Residential—Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.

22. High Intensity Residential—Includes highly developed areas where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80 to100 percent of the cover.

23. Commercial/Industrial/Transportation—Includes infrastructure (e.g., roads, railroads, etc.) and all highly developed areas not classified as High Intensity Residential.

Barren—Areas characterized by bare rock, gravel, sand, silt, clay, or other earthen material, with little or no "green" vegetation present regardless of its inherent ability to support life. Vegetation, if present, is more widely spaced and scrubby than that in the "green" vegetated categories; lichen cover may be extensive.

31. Bare Rock/Sand/Clay—Perennially barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, beaches, and other accumulations of earthen material.

32. Quarries/Strip Mines/Gravel Pits—Areas of extractive mining activities with significant surface expression.

33. Transitional—Areas of sparse vegetative cover (less than 25 percent of cover) that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g., fire, flood, etc.).

Forested Upland—Areas characterized by tree cover (natural or semi-natural woody vegetation, generally greater than 6 meters tall); tree canopy accounts for 25-100 percent of the cover.

41. Deciduous Forest—Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.

42. Evergreen Forest—Areas dominated by trees where 75 percent or more of the tree species `maintain their leaves all year. Canopy is never without green foliage.

43. Mixed Forest—Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.

Shrubland—Areas characterized by natural or semi-natural woody vegetation with aerial stems, generally less than 6 meters tall, with individuals or clumps not touching to interlocking. Both evergreen and deciduous species of true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions are included.

51. Shrubland—Areas dominated by shrubs; shrub canopy accounts for 25-100 percent of the cover. Shrub cover is generally greater than 25 percent when tree cover is less than 25 percent. Shrub cover may be less than 25 percent in cases when the cover of other life forms (e.g., herbaceous or tree) is less than 25 percent and shrubs cover exceeds the cover of the other life forms.

Non-Natural Woody—Areas dominated by non-natural woody vegetation; non-natural woody vegetative canopy accounts for 25-100 percent of the cover. The non-natural woody classification is subject to the availability of sufficient ancillary data to differentiate non-natural woody vegetation from natural woody vegetation.

61. Orchards/Vineyards/Other—Orchards, vineyards, and other areas planted or maintained for the production of fruits, nuts, berries, or ornamentals.

Herbaceous Upland—Upland areas characterized by natural or semi-natural herbaceous vegetation; herbaceous vegetation accounts for 75-100 percent of the cover.

71. Grasslands/Herbaceous—Areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is less than 25 percent, but exceeds the combined cover of the woody species present. These areas are not subject to intensive management, but they are often utilized for grazing.

Planted/Cultivated—Areas characterized by herbaceous vegetation that has been planted or is intensively managed for the production of food, feed, or fiber; or is maintained in developed settings for specific purposes. Herbaceous vegetation accounts for 75-100 percent of the cover.

81. Pasture/Hay—Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.

82. Row Crops—Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.

83. Small Grain—Areas used for the production of graminoid crops such as wheat, barley, oats, and rice.

84. Fallow—Areas used for the production of crops that do not exhibit visible vegetation as a result of being tilled in a management practice that incorporates prescribed alternation between cropping and tillage.

85. Urban/Recreational Grasses—Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

Wetlands—Areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al.

91. Woody Wetlands—Areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

92. Emergent Herbaceous Wetlands—Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

APPENDIX C: GAP LANDCOVER DESCRIPTION

Water—Open water

Spruce-Fir—Conifer forest principally dominated by combinations of spruce and sub-alpine fir. Primary associated tree species include lodgepole pine, white fir, Douglas fir, limber pine, and bristlecone pine.

Ponderosa Pine—Conifer forest principally dominated by ponderosa pine. Primary associated tree species include pinyon or juniper, white fir, and Douglas fir.

Mountain Fir—Conifer forest principally dominated by combinations of white fir and doug fir. Primary associated tree species include ponderosa pine, pinyon, spruce, and subalpine fir.

Juniper—Conifer forest principally dominated by juniper. Primary associated tree species include pinyon and mountain mahogany. Primary associated shrub species include sagebrush and blackbrush.

Pinyon—Conifer forest principally dominated by pinyon Pinus edulis or Pinus monophylla. Primary associated tree species include juniper Juniperus spp., ponderosa pine Pinus ponderosa, white fir Abies concolor, Douglas fir Pseudotsuga menziesii. Primary associated shrub species include oak Quercus gambelii and sagebrush Artemisa spp.

Pinyon-Juniper—Conifer forest principally co-dominated by pinyon and juniper. Primary associated tree species include mountain mahogany. Primary associated shrub species include sagebrush.

Aspen—Deciduous forest principally dominated by quaking aspen. Primary associated conifer species include spruce, fir, and pine. Primary associated shrub species include snowberry and serviceberry.

Oak—Deciduous shrubland principally dominated by gambel oak, palmer oak, wavyleaf oak, and shrub live oak. Primarily associated shrub species include maple Acer and sagebrush. Primary associated tree species include juniper, pinyon, ponderosa pine, aspen, and mountain mahogany.

Mountain Shrub—Deciduous shrubland principally dominated by alder leaf mountain mahogany, cliffrose, bitterbrush, serviceberry, buckbrush, chokecherry, snowberry, pointleaf, pungens, and bearberry. Primary associated shrub species include sagebrush, oak, and maple. Primary associated tree species include aspen.

Sagebrush—Shrubland principally dominated by big sagebrush, black sagebrush, low sagebrush , or silver sagebrush. Primary associated tree species include juniper, pinyon, mountain mahogany, and ponderosa pine. Primary associated shrub species include rabbitbrush, snakeweed, winterfat, shadscale, and bitterbrush.

Sagebrush/Perennial Grass—Co-dominate sagebrush shrubland and perennial grassland. Principle shrub species include sagebrush. Principle grass species include; bluebunch, wheatgrass, sandburg, crested wheatgrass, needlegrass, sand dropseed, blue gramma, thurbers needlegrass, western wheatgrass, indian ricegrass , and galleta. Associated principal shrub species include rabbitbrush, bitterbrush, and oak. Associated principal grass species include cheatgrass.

Grassland-Perennial and annual grasslands—Principle perennial grass species include bluebunch wheatgrass, sandburg bluegrass, crested wheatgrass, basin wildrye, galleta, needlegrass, sand dropseed, blue gramma, thurbers needlegrass, western wheatgrass, squirreltail, and indian. Principle annual grass species include cheatgrass. Primary associated shrub species include sagebrush, shadscale, greasewood, and creosote. Primary associated tree species include juniper.

Dry Meadow—Herbaceous dry meadow, including mostly forbs and grasses. Principal forb species include yarrow, dandelion, Richardson's geranium, mulesears, golden aster, arrowleaf balsamroot, hawkbit, larkspur, and scarlet. Principal grass species include wheatgrass, needlegrass, timothy, poa's, spike, and some sedges. Primary associated shrub species include sagebrush, rabbit brush, cinquefoil, snowberry, and elderberry.

Wet Meadow—Water saturated meadows, including mostly grasses, forbs, sedges and rushes. Principle species include sedges, rushes, reedgrass, timothy, hairgrass, willowherb, cinquefoil, etc. Primary associated species include willow, honeysuckle, and water birch .

Barren—Sand, rock, salt flats, pylas and lava.

Ponderosa pine/Mountain shrub—Conifer forest or woodland with principally Ponderosa pine dominate/associate or co-dominate with mountain shrubs. Principle mountain shrub associate species include manzanita, bitterbrush, tridentata, oak, snowberry, and curlleaf mountain mahogany. Primary associated tree species include juniper, pinyon, white fir, and Douglas fir. Primary associated shrub species are sagebrush and rabbitbrush.

Spruce-fir/Mountain shrub—Conifer forest or woodland with Spruce-Fir dominate/associate or co-dominate with mountain shrub. Principle tree species include Picea and sub-alpine fir. Principle shrub species include ribes, snowberry, ninebark, chokecherry, maple, mountain lover, blueberry, elderberry, grape, and serviceberry. Primary associated tree species include Douglas fir, lodgepole pine, white fir, and aspen. Primary associated shrub species include common juniper and sagebrush.

Mountain fir/Mountain shrub—Conifer forest or woodland with Mountain fir dominate/associate or co-dominate with mountain shrub. Principle tree species include Douglas fir and white fir. Principle shrub species include oak, maple, snowberry, grape, serviceberry, manainita, ninebark, and serviceberry. Primary associated tree species include alpine fir, englemann spruce, limber pine, ponderosa pine, and aspen. Primary associated shrub species include common juniper and sagebrush.

Aspen/Conifer—Deciduous forest with principally Aspen dominant or co-dominant with conifer. Principle conifer species include alpine fir, englemann spruce, limber pine, ponderosa pine, Douglas fir, and white fir.

Mountain Riparian—Riparian areas generally above 5500 feet. Principal woody species include willow, narrowleaf cottonwood, thinleaf alder, water birch, black hawthorn, rocky mountain maple, red-osier dogwood, and wild rose.

Lowland Riparian—Riparian areas generally lower than 5500 feet. Principal woody species include fremont cottonwood, Salt Cedar, netleaf hackberry, velvet ash, desertwillow, sandbar willow, and squawbush.

Agriculture—Row crops, irrigated pasture and hay fields, dry farm crops.

Urban—Commercial land and high density residential areas.

Salt desert scrub—Shrublands principally dominated by shadscale, gray molly, mat-atriplex, castle valley clover, winterfat, budsage, fourwing saltbush, halogeten, mormon tea, horsebrush, snakeweed, and rabbitbrush. Primary associated shrub species include greasewood, sagebrush, and blackbrush. Primary associated forb species includes halogeten.

Desert Grassland—Low elevation perennial grassland co-dominate with shrubland. Principal grassland species include galleta, indian ricegrass, three-awn, and sand dropseed. Principal shrub species include shadscale, rabbitbush, mormon tea, and winterfat. Principal forb species include desert trumpet.

Blackbrush—Shrubland principally dominated by blackbrush. Primary associated shrub species include spiny hopsage, mormon tea, shadscale, snakeweed, turpentine bush, and creosote. Other associated species include yucca and cacti.

Creosote-bursage—Shrubland principally dominated by creosote and white bursage. Primary associated shrub species include blackbrush, mormon tea, dalea, honey mesquite, and brittlebush. Other associated species include joshua tree, datil yucca, and prickly pear.

Greasewood—Shrubland principally dominated by greasewood. Primary associated shrub species include shadscale and pickleweed. Other associated species include seepweed and halogeten.

APPENDIX D: SURFACE WATER SAMPLING IN THE DUCHESNE RIVER WATERSHED

Table D-1. Summary of UDEQ stations with TDS data in the Duchesne River watershed

Station	Description	No. of Samples	Avg (mg/L)	Min (mg/L)	Max (mg/L)	Start Date	End Date
4934050	DUCHESNE R AB CNFL / GREEN R	34	891.74	228	1638	8/1/79	5/9/01
4934100	DUCHESNE R NEAR RANDLETT	230	962.33	184	2316	8/17/76	5/9/01
4934190	DUCHESNE R AT MYTON AT US40 XING	132	665.63	186	2222	8/1/79	6/7/01
4934210	OLD RIVER CHANNEL AB CNFL / GRAY MOUNTIAN CNL	3	862.67	664	1074	10/23/79	1/14/81
4934230	ANTELOPE CK AT US40 XING	23	2012.61	334	2764	10/15/80	5/28/96
4934250	SOWERS CREEK NEAR USNF BOUNDARY NEAR USGS GAGE 09288900	29	997.52	720	1364	5/19/87	6/7/04
4934460	DUCHESNE R BL DUCHESNE LAGOONS	5	495.60	316	822	7/28/76	4/26/01
4934480	DUCHESNE R AB DUCHESNE LAGOONS	58	341.79	100	876	2/5/75	4/5/88
4934500	DUCHESNE R AB CNFL / STRAWBERRY R	83	337.55	104	1800	8/1/79	6/7/01
4934530	INDIAN CAN CK AB CNFL / STRAWBERRY R	40	1860.05	290	2562	8/1/79	5/24/01
4935120	YELLOWSTONE R NEAR USFS BOUNDARY NEAR ALTONAH, UTAH	30	45.53	0	112	5/26/87	8/15/00
4935220	DUCHESNE R BL CNFL / ROCK CK	175	244.01	46	878	8/1/79	12/3/02
4935350	ROCK CREEK NEAR USNF BNDRY 12 MI NW OF MT HOME, UTAH	14	83.14	34	126	5/21/87	12/1/92
4935450	ROCK CREEK @ NFS BNDY	29	62.28	26	96	3/29/95	6/5/01
4935480	SO FK OF ROCK CREEK BL SO FK CAMPGRUOND BL R CK RANCH	2	48.00	44	52	4/7/88	7/2/91
4935490	ROCK CREEK BL UPPER STILLWATER RESERVOIR	23	38.43	0	76	5/12/88	6/28/94
4935530	ROCK CK AB STILLWATER RES	27	22.96	0	64	7/18/88	6/15/99
4935740	LAKE FORK R AB CNFL / DUCHESNE R	45	940.93	106	3390	8/1/79	6/7/01
4935750	DUCHESNE R AB CNFL / LAKE FORK R AT IRRIG DIVERSION	1	514.00	514	514	8/1/79	8/1/79
4935800	LAKE FORK R AT U87 XING S OF UPULCO	32	245.22	34	650	10/23/79	6/5/01
4935900	LAKE FK R BL MOON LAKE	3	26.00	22	30	6/10/75	7/17/79
4935950	BROWN DUCK CK AB MOON LAKE	24	34.33	0	144	8/10/78	8/30/01
4935970	LAKE FK R AB MOON LAKE	16	16.56	0	26	6/11/75	8/30/01
4935990	FISH CK AB MOON LAKE	2	33.00	22	44	6/26/75	10/2/75
4936010	RT FK INDIAN CAN CK AB CNFL / STRAWBERRY R	1	804.00	804	804	6/21/75	6/21/75
4936030	STRAWBERRY R BL STARVATION RES	27	440.41	46	632	2/9/75	10/16/90
4936120	DUCHESNE R AT KNIGHT DIVERSION	38	260.11	118	330	2/9/75	6/24/04

Station	Description	No. of Samples	Avg (mg/L)	Min (mg/L)	Max (mg/L)	Start Date	End Date
4936150	STRAWBERRY R AB STARVATION RES	236	425.07	168	990	6/21/75	6/30/04
4936160	STRAWBERRY RIVER BELOW CNFL / RED CREEK	17	354.24	300	392	7/6/88	10/16/90
4936170	RED CREEK AB CNFL / STRAWBERRY R	47	306.55	178	380	7/6/88	6/5/01
4936180	RED CREEK BL CNFL / CURRANT CREEK	32	326.50	264	396	5/21/86	10/16/90
4936190	CURRANT CREEK AB CNFL / RED CREEK	59	289.66	164	522	5/21/86	6/5/01
4936200	CURRANT CREEK BL CNFL / LAYOUT CK @ USFS BNDY	25	125.20	86	184	7/24/90	6/25/03
4936210	CURRANT CREEK BELOW CURRANT CREEK RESERVOIR	13	117.23	62	268	8/20/87	10/3/91
4936220	TIMBER CANYON AB FOREST BNDRY	4	381.00	294	500	7/2/90	6/3/03
4936230	TIMBER CANYON CK AB CNFL / SHOTGUN DRAW	1	350.00	350	350	7/2/90	7/2/90
4936240	SAND WASH AB CNFL / RED CREEK	1	1866.00	1866	1866	3/11/87	3/11/87
4936250	RED CREEK AB CNFL / CURRENT CK	62	616.15	198	1780	4/9/86	6/5/01
4936260	AVINTAQUIN CANYON CK AB STRAWBERRY RIVER	47	461.96	230	714	7/6/88	6/5/01
4936270	STRAWBERRY R AB CNFL / RED CREEK	17	337.18	268	374	7/6/88	10/16/90
4936280	TIMBER CANYON CK AB CNFL / STRAWBERRY R T4SR8W	11	414.91	370	530	7/6/88	8/14/90
4936290	WILLOW CREEK BL CNFL / FRENCH HOLLOW	12	348.00	314	390	7/24/90	7/1/03
4936300	STRAWBERRY R BL SOLDIER CK DAM	47	188.23	148	296	6/26/79	7/2/02
4936470	STRAWBERRY AQUADUCT AB STRAWBERRY RESERVOIR	12	121.17	46	194	3/7/89	10/4/91
4936510	TROUT CK AB STRAWBERRY RES AT US40 XING	8	163.00	152	182	6/26/79	10/14/03
4936520	STREEPER CREEK AB INDIAN CREEK ROAD	8	312.25	288	332	7/25/00	7/6/04
4936530	CO-OP CREEK ABOVE CNFL/ STRAWBERRY RIVER	6	157.33	130	238	9/14/00	1/8/02
4936540	STRAWBERRY R AB STRAWBERRY RES	4	204.25	150	228	6/26/79	9/23/80
4936550	INDIAN CREEK AB MOUTH OF STREEPER CREEK	7	353.71	324	388	7/25/00	7/6/04
4936560	CO-OP CREEK @ NARROWS 1 1/4 MI BL USFS BNDY	10	154.00	130	192	9/12/00	7/13/04
4936580	TRAIL HOLLOW CREEK AB CNFL / CHIPMAN CREEK	9	260.67	190	332	7/25/00	11/8/01
4936590	BRYANT S FORK CK AB STRAWBERRY RES	1	180.00	180	180	6/17/80	6/17/80
4936600	MUD CK AB STRAWBERRY RES	2	174.00	172	176	6/17/80	5/29/03

Station	Description	No. of Samples	Avg (mg/L)	Min (mg/L)	Max (mg/L)	Start Date	End Date
4936610	INDIAN CK AB WESTSIDE RD AB STRAWBERRY RES	44	332.34	234	1858	6/29/79	7/13/04
4936620	CLYDE CREEK BELOW WESTSIDE ROAD	5	200.40	192	210	9/14/00	10/14/03
4936630	CLYDE CREEK AB OLD NATIONAL FOREST BOUNDARY	5	210.80	202	224	9/13/00	10/14/03
4936640	CHICKEN CK AB STRAWBERRY RES	2	135.00	100	170	6/26/79	6/17/80
4936650	STRAWBERRY RIVER AT WESTSIDE ROAD	52	212.27	130	370	10/13/97	7/13/04
4936660	STRAWBERRY R BL CNFL/ WILLOW CREEK	3	314.67	264	342	9/14/00	7/12/04
4936680	STRAWBERRY RIVER AB DANIELS DIVERSION	4	208.00	192	226	7/26/00	7/19/04
4936700	WIDE HOLLOW CK AB CNFL / STRAWBERRY R	4	198.50	174	218	7/26/00	7/19/04
4936720	DUCHESNE R AT U208 XING BL TABIONA	123	283.56	106	394	8/1/79	9/27/94
4936730	RUNOFF FROM FEEDLOT TO DUCHESNE R NR "THE POINT"	2	367.00	366	368	4/27/89	5/10/89
4936740	WARM SPRINGS AT ENTRY TO DUCHESNE RIVER	13	333.08	154	460	5/10/89	10/16/90
4936750	DUCHESNE R AB TABIONA BL CNFL / W FK DUCHESNE R	78	231.10	94	2052	11/3/77	6/29/04
4936770	N FK DUCHESNE R ABOVE CNFL / W FK DUCHESNE R	72	126.42	42	280	9/22/88	12/3/02
4936780	WOLF CK BL TWIN CK DIVERSION	47	181.23	106	232	5/5/92	12/3/02
4936800	WEST FORK DUCHESNE RIVER ABOVE VAT CK DIV DAM	21	238.10	152	282	8/20/87	7/13/04
5934640	TRIBUTARY TO LAKE FK R BL TWIN POTS RES	1	0.00	0	0	7/1/81	7/1/81
5934660	FARNSWORTH CNL AB TWIN POTS RES	1	0.00	0	0	7/1/81	7/1/81
5935140	CNL BL L BOREHAM	1	412.00	412	412	6/30/81	6/30/81
5935180	MIDVIEW DITCH AB L BOREHAM	2	319.00	214	424	6/6/90	7/12/95
5936040	DUCHESNE R BL MIRROR L	1	0.00	0	0	6/24/81	6/24/81
5936230	RED CK AB RED CK RES	9	259.11	218	286	5/26/92	8/29/00
5936480	CURRANT CREEK AB PASS CREEK AND RESERVOIR	11	225.64	174	304	6/26/91	8/30/01
5936490	RACE TRACK CREEK AB CURRANT CREEK RESERVOIR	11	82.91	42	230	6/26/91	6/21/01
5936500	PASS CREEK AB CURRANT CREEK AND RESERVOIR	11	204.36	68	292	6/26/91	6/21/01
5936510	LOW PASS CREEK AB CURRANT CREEK RESERVOIR	12	215.83	156	304	6/26/91	8/30/01
5936520	ROCK CREEK DIVERSION AB CURRANT CREEK RESERVOIR	9	114.44	20	452	9/3/91	8/30/01

Table D-2. Summary of USGS stations with TDS data in the Duchesne River watershed

Station	Description	No. of Samples	Avg (mg/L)	Min (mg/L)	Max (mg/L)	Start Date	End Date
09275000	W F DUCHESNE RIVER BL DRY HOLLOW NR HANNA, UT	3	205.00	162	269	8/21/1957	5/12/1964
09275500	WEST FORK DUCHESNE RIVER NEAR HANNA, UT	5	255.60	185	343	8/16/1956	6/7/1962
09277000	DUCHESNE R (@ 'THE POINT'), @ HANNA, UTAH	43	238.30	113	300	8/21/1957	9/1/1964
09279150	DUCHESNE RIV ABV KNIGHT DIVERSION, NR DUCHESNE, UT	85	224.20	78	355	4/30/1958	9/4/1973
09279500	DUCHESNE RIVER AT DUCHESNE, UTAH	84	257.30	92	1030	5/18/1941	5/22/1974
09295000	DUCHESNE RIVER AT MYTON, UT	60	780.17	227	1810	4/20/1941	9/19/1994
09302000	DUCHESNE RIVER NEAR RANDLETT, UT	738	1063.79	115	3330	10/1/1957	8/14/2003
400509109404500	DUCHESNE RIVER @ MOUTH, @ OURAY, UTAH	5	928.60	257	1720	4/21/1941	3/25/1968
400947110230300	DUCHESNE R BL STRAWBERRY R @ DUCHESNE, UTAH	1	265.00	265	265	5/22/1974	5/22/1974
401002110171200	DUCHESNE RIVER AB GREY MTN CAN NR BRIDGELAND UT	2	420.00	414	426	4/19/1941	5/7/1959
401016110181100	DUCHESNE R AB DUCHESNE FEED CA NR BRIDGELAND, UT	85	359.60	143	1280	4/4/1962	9/6/1973
401120109452900	DUCHESNE RIVER AT WISSIUP CANAL NR RANDLETT, UT	26	1694.42	556	3180	5/8/1959	2/1/1962
401135109545600	DUCHESNE RIVER @ OURAY SCH CANAL NR RANDLETT,UT	48	1425.98	209	4040	2/14/1956	2/1/1962
401212110062001	DUCHESNE RIVER @ MYTON TOWNSITE CA NR MYTON, UT	20	613.20	142	1480	5/7/1959	7/7/1965
401245109472800	DUCHESNE RIVER ABOVE UINTA RIVER NR RANDLETT, UT	6	1192.50	733	1660	7/11/1973	9/17/1973
402112110424701	DUCHESNE RIVER @ TABIONA, UTAH	1	256.00	256	256	7/31/1946	7/31/1946

APPENDIX E: SUMMARY OF BEST MANAGEMENT PRACTICES

This appendix provides information on available BMPs to control TDS loading in the Duchesne River watershed, as identified in Table E-1. Salinity control BMPs included in NRCS's National Handbook of Conservation Practices is provided for general information on the types of salinity control practices available and currently used in the watershed. In addition, descriptions are provided for specific BMPs identified in Section 8 as potential controls for expected sources in the Duchesne River watershed. The BMP descriptions are adapted from those provided in UDEQ's *TMDL Water Quality Study of the Virgin River Watershed: Appendix B: Implementation Measures*. Practices described are meant to be implemented in areas adjacent to the stream channel or water body. However, many of the treatments can be used effectively in uplands and other areas. It should be noted that while practices may sometimes be effective when used separately, an implementation strategy using two or more complimentary practices generally provides better results. Any strategy for reducing pollution loads should work to eliminate the underlying causes of the pollution as well as the identified source.

Table E-1. Reports describing potential BMPs for salinity control in the Duchesne River watershed

Document Title/Web Site	Summary	
National Handbook of Conservation Practices; USDA-NRCS, July 2002, http://www.nrcs.usda.gov/technical/Standards/nhcp.html	Prepared by the NRCS, a division of the U.S. Department of Agriculture, to educate landowners in conservation programs and applications. Information is provided in general terms to guide program development. The conservation practice must be developed by NRCS personnel within the state in which you are working to insure that all federal, state, and local criteria are met. 1. Irrigation water management 2. Runoff management system 3. Soil salinity management—non-irrigated 4. Toxic salt reduction	
TMDL Water Quality Study of the Virgin River Watershed: Appendix B: Implementation Measures; January 2004, Submitted to UDEQ (Prepared by Tetra Tech). http://www.waterquality.utah.gov/TMDL/lower%20colorado%20final%20draft%20TMDL.pdf	This summary provides a manual for landowners, managers and technicians to adopt effective and appropriate practices to reduce both point and non-point source pollutants (i.e., TDS) from entering streams and watercourses.	
	<u>Level 100: Passive Management</u> #120: Grazing management #140: Irrigation water management <u>Level 200: Active Management</u> #210: Exotic removal #220: Fencing #221: Seeding #240: Filter strip #260: Pole/post planting <u>Level 300: Mild Engineering</u> #301: Brush layer #302: Brush mattress #303: Brush revetment #304: Vertical bundle #305: Willow fascines	#330: Brush trench #331: Erosion control fabric #332: Fiberschines/biologs #333: Silt fence #334: Straw roll/bale barrier #370: Watering facility <u>Level 400: Moderate Engineering</u> #420: Grade stabilization structure #450: Irrigation pipeline #451: Irrigation system, drip #452: Irrigation system, sprinkler #453: Irrigation system, surface #470: Road stabilization <u>Level 500: Intense Engineering</u> #500: Constructed wetland

E.1 NRCS Guidance on Conservation Practices

The NRCS has established a handbook of conservation practices to guide landowners in implementing pollutant control systems. The practices described here are vague, as it is the practice of the NRCS to work with individual landowners to design and implement site-specific conservation practices. Additional information is offered on the NRCS Web site regarding conservation practice standards, information sheets, and an analysis of physical effects resulting from the application of conservation techniques. NRCS administers a number of cost-share programs under the Farm Bill to provide on-the-ground assistance to landowners. These programs can be valuable in providing financial support to meet project goals. Virtually all of these practices are approved under NRCS-funded programs.

1. Irrigation Water Management
NRCS, NHCP Code 449

Irrigation water management is the process of determining and controlling the volume, frequency, and application rate of irrigation water in a planned, efficient manner. Irrigation water management is applied as part of a conservation management system to support one or more of the following:

- Manage soil moisture to promote desired crop response
- Optimize use of available water supplies
- Minimize irrigation induced soil erosion
- Decrease nonpoint source pollution of surface and ground water resources
- Manage salts in the crop root zone
- Manage air, soil, or plant micro-climate

This practice is applicable to all irrigated lands. An irrigation system adapted for site conditions (soil, slope, crop(s) grown, climate, water quantity and quality, etc.) must be available and capable of applying water to meet the intended purpose(s). This practice does not apply to "wild flood" situations. All work shall comply with federal, state and local laws and regulations. Water shall not be applied in excess of the amounts needed to meet the intended purpose(s). The National and Utah Irrigation Guide will be used as a reference for developing Irrigation Water Management specifications.

The following principles shall be applied for various crop growth stages:

- The volume of water needed for irrigation shall be determined on the basis of plant requirements, available water holding capacity of the soil for the crop rooting depth, management allowed soil water deletion, irrigation efficiency, and water table contributions.
- The irrigation frequency shall be determined on the basis of the volume of irrigation water to be applied and/or available, crop evapotranspiration, and effective precipitation.
- The application rate shall be determined on the basis of the volume of water to be applied, the frequency of irrigation applications, soil infiltration and permeability characteristics, and the capacity of the irrigation system.

Irrigation systems will be managed to achieve the following minimum seasonal irrigation efficiencies: center pivot, linear move, level and graded border 80 percent, trickle 70 percent, sprinkler 60 percent, surface 50 percent, and contour ditch 25 percent. Additionally, program administrators will evaluate the amount of available water relative to the irrigated acreage and manage to optimize crop production. Irrigation application rates and length of runs shall be consistent with field slopes, soil textures, and residue management to minimize irrigation-induced soil erosion. Irrigation water shall be applied at rates that minimize runoff and/or leaching of sediments, nutrients, pesticides, or other pollutants to surface and groundwater. The irrigation application volume shall be increased by the amount required to maintain an appropriate salt balance in the soil profile. The requirement shall be made on the basis of the leaching procedure contained in the *National Engineering Handbook*, Part 623, Chapter 2. The irrigation system shall have the capacity to apply the required rate for frost protection or crop and soil cooling as also outlined the handbook.

The following items should be considered when planning irrigation water management:

- Consider operator objectives and management abilities, water delivery schedule, economics, and operation and maintenance requirements.
- Consider managing precipitation effectiveness, crop residues, and reducing system losses.
- Modify plant populations, crop and variety selection, and irrigated acres to match available or anticipated water supplies.
- Consider potential for spray drift and odors when applying agricultural and municipal wastewater.
- Consider making equipment modifications or soil amendments such as polyacrylamides and mulches to decrease irrigation-induced erosion.
- Consider the quality of water and the potential impact to crop quality and plant development.
- Consider the quality of irrigation water relative to its potential effect on the soil's physical and chemical properties, such as soil crusting, pH, permeability, salinity, and structure.
- Avoid traffic on wet or moist soils to minimize soil compaction.
- Consider the effects that irrigation water has on wetlands, water related wildlife habitats, riparian areas, cultural resources, and recreation opportunities.
- Consider implementing additional practices such as nutrient and pesticide applications when scheduling leaching events to avoid groundwater pollution.
- Consider electrical load control or interruptible power schedules, repair and maintenance downtime, and harvest downtime.
- Consider improving the irrigation system to increase distribution uniformity or irrigation water application.
- Consider the effects of tailwater runoff and other potential off-site impacts.

Application of these practices will include, as a minimum, specification sheets or similar documents that specify the water supply, method of irrigation, crops grown, soils, variations in soil and water supply, crop needs, irrigation scheduling, and monitoring necessary for applying and maintaining the practices to achieve the intended purpose.

There are no operation and maintenance (O&M) aspects applicable to this standard. Necessary O&M items are addressed in the physical component standards considered companions to this standard. Consultation with NRCS personnel is required to establish a site-specific irrigation water management program.

2. Runoff Management System
NRCS, NHCP Code 570

The definition of a runoff management system is a system for controlling excess runoff caused by construction operations at development sites, changes in land use, or other land disturbances. This standard applied to the planning, design, installation, operation, and maintenance of runoff management systems, including adequate outlet facilities and components required for adequate management of storm runoff, as determined by site conditions. The purpose of this system is mainly to regulate the rate and amount of runoff and sediment from development sites during and after construction operations to minimize such undesirable effects as flooding, erosion, and sedimentation. The practice is applied if there is a need to control runoff, erosion, and sedimentation to compensate for increase peak discharges and erosion resulting from construction operations at development sites or from other changes in land use. The discharges might be caused by such factors as increased runoff, reduced time of concentration, and reduced natural storage.

Planning Considerations

A. Water Quantity

The following issues related to water quantity should be considered:

- The effect of onsite detention on decreased runoff volume and peak flow, potentially increased infiltration, and the effectiveness of infiltration devices and controlled outlets.
- Potential changes in evapotranspiration of vegetation in the infiltration areas and changes in soil moisture storage and volume of deep percolation.

B. Water Quality

The following issues related to water quality should be considered:

- The effects of reduction in erosion and sediment yield, with reductions in construction related pollutants adsorbed on sediments.
- The effects of increases in dissolved nutrients and other chemicals through increased infiltration and deep percolation.
- The effects on the visual quality of decreased sediment in downstream water resources should be considered in planning for site-specific conditions.

A runoff management system must be compatible with the flood plain management program of the local jurisdiction and with local regulations for controlling sediment, erosion, and runoff. The system, a single component, or a combination of components must properly regulate storm discharges from a site to a safe, adequate outlet. Consideration shall be given to the duration of flow as well as the peak discharge. The peak discharge from the 2-year and 100-year, 24-hour storm shall be analyzed. No increase in peak from these storms shall be allowed unless downstream increases are compatible with the overall flood plain management system.

Adequate erosion-control measures and other water-quality practices must be provided. The components must be planned and designed to insure minimal impact on visual quality and human enjoyment of the landscape. Structures and materials must harmonize with surrounding areas. Components to implement erosion control measures include, but are not limited to, dams, excavated ponds, infiltration trenches, parking lot storage, rooftop storage, and underground tanks. Each component shall be designated according to sound engineering principles to insure that the system achieves its intended purpose. Design criteria for individual components shall be based on accepted industry standard practices. Coordination with NRCS staff will direct the application of specific design criteria. Plans and specifications for runoff management systems shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. Landscape architectural practices must ensure that all measures are visually compatible with the surrounding landscape. A protective cover of grasses shall be established on exposed surfaces and other disturbed areas. Other protective measures, such as mulches, also can be used. Seedbed preparation, seeding, fertilizing, and mulching shall comply with recommendations in technical guides.

Components shall be designed and installed in a sequence that permits each to function as intended without causing a hazard. Single components shall not be installed until plans for the entire runoff management system are completed. Appropriate safety features and devices shall be installed to protect humans and animals from such accidents as falling or drowning. Temporary fencing can be used until barrier plantings are established. Such protective measures as guardrails and fences shall be used on spillways and impoundments as needed.

A plan of operation and maintenance shall be prepared for use by the owner or others responsible for the system to insure that each component functions properly. This plan shall provide requirements for inspection, operation, and maintenance of individual components, including outlets. It shall be prepared before the system is installed and shall specify who is responsible for maintenance. Adequate rights-of-way must be provided for maintenance access.

3. Soil Salinity Management—Non-irrigated NRCS, NHCP Code 571

The definition of soil salinity management includes applications to land, water, and plants to control subsurface soil water movement and to minimize accumulations of salts on the soil surface and in the root zone of non-irrigated saline seep areas. The purpose of this practice is to promote desired plant growth in non-irrigated saline seep areas. This practice applies to non-irrigated land where a combination of factors such as topography, soils, geology, precipitation, vegetation, land use, and cultural/structural practices can increase the extent and soluble salt concentrations of saline seep areas.

The use of fertilizers, pesticides or other chemicals and soil amendments shall not compromise the intended purpose. A Non-irrigated Soil Salinity Management Plan will be developed to document the extent and planned management of recharge and saline seep areas. Additionally, recharge areas will be delineated in the Management Plan. Plant or maintain adapted high water use vegetation in recharge areas to utilize soil water, minimize infiltration and decrease subsurface soil water movement to saline seep areas. Where practicable, divert run-on or install surface or subsurface drainage to minimize infiltration and decrease soil water in recharge areas. Saline seep areas will be outlined in the Management Plan to establish adapted vegetation in reclaimed saline seep areas after water tables have been lowered sufficiently to prevent capillary movement of water and salts into the root zone and to the soil surface. Some conditions should be considered prior to applying a non-irrigated soil salinity management plan. The objective is to apply practices in the reclaimed saline seep to help increase infiltration and leaching. Methods of accomplishing this objective include the following:

- Eliminate fallow periods in recharge areas to increase utilization of soil water and decrease infiltration.
- Locate snow fences, windbreaks, vegetative filter strips, and other structures that may accumulate rain and snow away from recharge areas.
- Seal the bottoms of constructed ponds or dugouts to minimize subsurface soil water movement to saline seep areas.
- Install underground outlets or surface waterways to drain storage terraces and minimize infiltration.
- Plug leaky artesian wells if they contribute to subsurface water flows.
- Install or improve culverts to minimize blockage or surface water flows. Roadways that cross natural drainageways can impede surface water flows and increase infiltration.
- Plant cover or crops in recharge areas to use excess water if the planned crop fails due to conditions such as poor stand establishment, hailstorms, winterkill, disease, or insect damage.
- Plant deep-rooted trees or shrubs in the recharge area to use excess soil water.

Non-irrigated Soil Salinity Management Plan

Plans for Non-irrigated Soil Salinity Management shall include the following components:

- An Onsite Investigation Report.
- Conservation practices and specifications to be implemented in recharge areas to increase soil water utilization and decrease subsurface soil water movement to the saline seep areas.
- Conservation practices and specifications to be implemented to reclaim saline seep areas after water table elevations have been lowered sufficiently to prevent capillary movement of water and salts into the root zone and to the soil surface.
- Monitoring activities that may be needed to evaluate practice implementation and effectiveness.

An onsite investigation will be conducted to identify existing field conditions, delineate recharge and saline seep areas, and to gather supporting data for development of the Non-irrigated Soil Salinity Management Plan. The Onsite Investigation Report will include the following information for recharge and saline seep areas: location maps, including field numbers and measured acres, groundwater elevations; soil tests to evaluate fertility; pH; electrical conductivity (EC); free lime (calcium carbonate); SAR; topographic, soils and geologic maps; and historic photographs or cropping and yield histories that document saline seep development and extent. Reclamation of saline seep areas with SAR values of 13 and greater (saline/sodic soils) may require amendment applications, as determined by soil testing, to replace adsorbed sodium with soluble calcium.

For operation and maintenance of a non-irrigated soil salinity management program, administrators should identify any required items needed to assist in stand establishment such as mowing, flash grazing and/or herbicides to control weeds and administrators should also address insect and disease control needs where they are likely to create establishment problems. Any necessary replanting due to drought, insects, or other uncontrollable events that prevent adequate stand establishment should be addressed as soon as possible. Replanting activities may vary from complete reestablishment to overseeding or spot replanting.

4. Toxic Salt Reduction
NRCS, NHCP Code 610

Toxic salt reduction is the practice of reducing or redistributing the harmful concentrations of salt or sodium in a soil. This method is sometimes referred to as leaching. The purpose of toxic salt reduction is to permit desirable plants to grow. This practice applies on land where the accumulation of salt at or near the surface limits the growth of desirable plants.

Planning Considerations

A. Water Quantity

The following issues related to water quantity should be considered:

- Effects on the water budget, especially on infiltration, deep percolation, and groundwater discharge.
- The variability (volume and timing) of the leaching fraction, the need for additional irrigation water, and the impact of drainage (if installed as an associated practice).

B. Water Quality

The following issues related to water quality should be considered:

- Effects on irrigation-induced erosion, sedimentation, and soluble sediment-attached substances in irrigation tailwater.
- Effects of leaching on the volume of toxic salts and soluble nutrients and pesticides removed from the root zone.
- The ultimate residence of the chemicals and the surface and ground water impact of drainage (if installed as an associated practice).

E.2 Suggested Implementation Measures

Information contained on the following pages was taken from the *TMDL Study of the Virgin River Watershed, Appendix B: Implementation Measures* (UDEQ, 2004b). The Practice Number categorizes the BMPs by technical level of expertise required to successfully design, install, and maintain specific practices.

Level 100: Passive Management includes practices that can generally be implemented without significant capital costs or an increase in infrastructure. Examples of passive management are restricted or rotational grazing, changes in timing and extent of irrigation, changes in type or amount of fertilizer used, and abandonment and rehabilitation of roads or other disturbed areas.

Level 200: Active Management describes practices that can generally be implemented directly by a landowner or manager. However, these practices generally require some costs to improve or update infrastructure. Examples of active management include fencing, creating buffer strips, and establishing vegetation.

Level 300: Mild Engineering practices are those that not only require active efforts but also assistance from appropriate technical resources. Technical resources could include the Extension Service, NRCS, and other agency or private practitioners. Practices in this category include a variety of bioengineering practices to reduce streambank erosion, off-channel water sources, and irrigation tailwater recovery.

Level 400: Moderate Engineering practices are those that entail a greater risk of failure without appropriate technical expertise. These practices are more expensive and have greater risk of failure. Practices include structural bank protection, structural gully stabilization, and design and installation of more efficient irrigation systems.

Level 500: Intense Engineering practices generally require significant engineering and other technical expertise in both design and construction to ensure success. These practices are generally most expensive and have a significant risk of failure if not implemented correctly. Practices include diversion dams and other primary instream structures, grade stabilization structures in large stream channels, stream channel realignments and waste storage or treatment lagoons. These practices generally require professional engineering or other technical assistance.

Level 100 Practices

Grazing Management, Practice #120, Passive Management

Grazing management is the process of managing the controlled harvest of vegetation with grazing animals. The duration and intensity of grazing should be determined on the basis of desired plant health and expected productivity of key forage species to meet management unit objectives. Management may be exclusion, seasonal rotation, rest, or some combination. The purpose is to improve or maintain the health and vigor of plant communities, to improve or maintain water quality or reduce accelerated soil erosion, and maintain/improve soil conditions. Proper management provides a healthy plant community that stabilizes soil, creates habitat, slows flood velocities, and often provides greater amounts of forage. This practice can be applied to agricultural lands and riparian areas. It has a moderate load reduction potential with improvements observed within a few months to a couple of years after implementation. This practice has low maintenance requirements and addresses sediments, pathogens, nutrients, temperature, and low dissolved oxygen.

The removal of all herbage will be done in accordance with site production limitations, rate of plant growth, and the physiological needs of forage plants. Management options must be provided for the type of animal, animal number, grazing distribution, length of grazing periods, and timing of use to provide sufficient deferment from grazing during the growth period. Planning considerations must protect soil, water, air, plant and animal resources when locating livestock feeding, handling and watering facilities. Effective management of grazing animals must be implemented to maintain adequate vegetative cover on sensitive areas (e.g., riparian, wetland, habitats of concern). The duration and intensity of grazing will be determined on the basis of desired plant health and expected productivity of key forage species to meet management unit objectives. Program administrators need to consider the adjustment of grazing periods or stocking rates to meet the desired objectives for the plant communities and the associated resources, including the grazing animal. This will include scheduling livestock movements considering rate of plant growth, available forage and utilization, not calendar dates. Periodic rest from grazing may be needed to maintain or restore the desired plant community following episodic events, such as wildfire or severe drought. Other considerations include maintaining adequate ground cover and plant density to sustain or improve the filtering capacity of the vegetation, and minimizing the concentrated livestock areas to enhance nutrient distribution and improve or maintain ground cover.

Irrigation Water Management, Practice #140, Passive Management

Irrigation water management is the process of determining and controlling the volume, frequency, and application rate of irrigation water in a planned and efficient manner. Effective management produces larger crops and reduces water demand and unintentional return flows. This process effectively uses the available irrigation water in managing and controlling the moisture environment of crops and other vegetation. The objectives of this agricultural practice are to promote a desired response, minimize soil erosion, minimize loss of plant nutrients, and protect both the quantity and the quality of water resources. This practice addresses sediments, salinity, pesticides, low dissolved oxygen, nutrients, and organics. Moderate reduction potential results from implementation and results can be observed immediately with low maintenance required.

Level 200 Practices

Exotic Removal, Practice #210, Active Management

This practice involves removing exotic plant species that compete with native vegetation or destabilizes stream channels. Exotic plant species can create conditions that greatly increase either streambank erosion or gullying and can outcompete native vegetations, thus decreasing the available forage and habitat. The purpose of this practice is to restore natural plant community balance, to reduce the competition for space, moisture, and sunlight between desired and unwanted plants. Additionally, this practice assists in the management of noxious woody plants by restoring desired vegetative cover to protect soils, control erosion, reduce sediment, improve water quality, and enhance stream flow. Exotic removal practices maintain or enhance wildlife habitat including that associated with threatened and endangered species. This practice can be applied streamside with moderate potential to reduce the load. Results can be observed immediately with moderate maintenance requirements.

There are three types of methods to apply exotic removal of plant species: mechanical, chemical, and biological treatment. For mechanical treatment methods, plans and specifications will include the types of equipment to adequately complete the job. Also included should be the dates of treatment, operating instructions and techniques or procedures to be followed. For chemical treatment methods, plans and specifications should include the herbicide name, rate of application or spray volume, acceptable dates of application, mixing instructions (if applicable), any special application techniques, timing considerations, or other factors that must be considered to ensure the safest most effective application of the herbicide and reference to label instructions. For biological treatment methods, plans and specification shall include the kind of biological agent or grazing animal to be used, the timing, duration and intensity of grazing or browsing, desired degree of grazing or browsing use for effective control of the target species, and any special precautions or requirements when using insects or plants as control agents.

Fencing, Practice #220, Active Management

A fence is a constructed barrier to livestock, wildlife, or people. This practice may be applied to any area where livestock or wildlife control is needed, or where access to people is to be regulated. The purposes are the following:

- Reduce sheet and rill erosion, wind erosion, ephemeral gully erosion, classic gully erosion and streambank erosion
- Reduce surface water contamination from suspended sediments
- Improve plant suitability, plant productivity, and plant health
- Improve aquatic habitat suitability

This practice can be applied streamside and on agricultural and developed lands. There is a high load reduction potential with low maintenance required and immediate results observed.

A wide variety of types of fencing have been developed. However, fencing material and construction quality is always designed and installed to assure the fence will meet the intended purpose and longevity requirements of the project. The standard fence is constructed of either barbed or smooth wire suspended by posts with support structures. Other types include woven wire for small animals, electric fences and suspension fences, which are designed with heavy but widely spaced posts and support structures. Things to consider when installing a fence include avoiding as much irregular terrain as possible, feasibility of constructing a fence on steep and irregular terrain, movement of wildlife, state and local laws pertaining to boundary fences, livestock handling, watering and feeding requirements, and soil erosion potential.

Seeding, Practice #221, Active Management

Seeding is used to establish forage species by applying an herbaceous seed mix to disturbed areas usually by broadcasting, mulching, hydroseeding, or aerial seeding. The purpose is to revegetate disturbed areas of ground to prevent soil erosion. Generally, grass seed is applied to revegetate bare or disturbed ground. In and around wetlands and riparian areas, wetland seed mixes are used. There is a moderate load reduction potential with results observed in a few months to a year after application. The expected maintenance is low with streamside, agricultural, and developed lands as potential treatment areas. Successful seeding requires the use of appropriate plant seeds sowed during the appropriate time of the year. In general, the seed is covered with mulch, a compost, or hydromulch to retain moisture, protect the seed, and provide cover.

Filter Strip, Practice #240, Active Management

A strip or area of herbaceous vegetation situated between crop land, grazing land, or disturbed land and environmentally sensitive areas provides a means of removing pollutants from runoff before materials enter a body of water. It also serves as a buffer between water and the fields above the water so that pesticides and other chemicals are not directly applied adjacent or into the water body. Filter strips reduce sedimentation of streams, lakes, and other bodies of water effectively addressing pollutants such as salinity, pesticides, pathogens, heavy metals, dissolved oxygen, nutrients, and organics. This method has a high potential to reduce loading into watercourses with results evident in a few months to 2 years after application. The required maintenance of this technique is low and can be applied to agricultural and developed lands.

Filter strips should be strategically located to reduce runoff and increase infiltration and groundwater recharge throughout the watershed. For the purposes of improving wildlife habitat and improving watershed functionality, these strips should be placed to intercept contaminants, thereby enhancing water quality of the watershed. Consider this practice to enhance the conservation of declining species of wildlife, including those threatened or endangered. Consider using this practice to protect National Register listed or eligible (significant) archeological and traditional cultural properties from potential damaging contaminants. Filter strip size should be adjusted to a greater flow length to accommodate harvest and maintenance equipment. To avoid damage to the filter strip, consider using vegetation that is somewhat tolerant to herbicides used in the upslope crop rotation.

Pole/Post Planting, Practice #260, Active Management

Pole/post planting establishes woody plants by planting or transplanting seedlings, saplings, or cuttings, direct seeding, or natural regeneration. The purpose of this activity is to establish woody plants for forest products, wildlife habitat, long-term erosion control and improvement of water quality, waste treatment, reduction of air pollution, sequestration of carbon, energy conservation and enhancement of the aesthetic appearance of an area. This practice has a moderate potential of reducing sediments, salinity, water temperatures, low dissolved oxygen, nutrients and organics. Improvements are seen within a few months to two years after implementation and low maintenance is required to sustain the practice. This activity can be implemented streamside and on agricultural and developed lands. No permits are necessary as long as the streambanks are manually sloped.

Priority should be given to locally adapted seed, seedlings or cuttings that have been selected and tested in tree/shrub improvement programs. All plant materials should comply with a minimum standard, such as the American Nursery and Landscape Association, the USFS, or state-approved nursery.

Plants for landscape and beautification plantings should consider foliage color, season, color of flowering, and mature plant height. Where multiple species are available, consideration should be given to selecting species that best meet wildlife needs. Tree/shrub arrangement and spacing should allow for and anticipate the need for future access lanes for purposes of stand management. Residual chemical carryover should be evaluated prior to planting to determine the environmental tolerance of plantings. Species considered locally invasive or noxious should not be used. Species used to treat waste should have rapid growth characteristics and extensive root systems, be capable of high nutrient uptake, and produce wood/fiber products in short rotations. For optimal carbon storage, select plant species that are adapted to the site to assure strong health and vigor and plant at the full stocking rate for the site.

Level 300 Practices

Brush Layer, Practice #301, Mild Engineering

The brush layer technique involves placing bundles of willow cuttings (*Salix spp.*) in buried trenches along the slope of an eroding streambank. The willow "terrace" is used to reduce the length of slope of the streambank. Plantings are directed towards the stream, providing coverage over the watercourse. The willow cuttings will sprout and take root, thus stabilizing the streambank with a dense matrix of roots. Some toe protection such as wattle, fiberschine, or rock may be necessary with this technique. This technique is applied streamside, has low maintenance, and reduces a high load potential for sediments, salinity, nutrients and organics, water temperature, and habitat alteration.

No permits are required if plants are installed by hand. However, if toe rock is used, permits under Section 401 and 404 of the Clean Water Act may be required. In many cases, toe rock will be necessary to provide adequate protection. In addition to toe protection, erosion control fabric can be used to protect the soil between the layers.

Coyote willow (*Salix exigua*) is an especially good species for this method because of its dense rooting system. This technique can also be used with a mixture of redoiser dogwood (*Cornus sericea*) and willow, but to encourage rooting in the dogwood, the stems will need to be manually nicked or cut and treated with rooting hormone.

A critical inventory step is to determine the availability of moisture to the cuttings. This technique is best applied to areas with bank seepage to supply enough moisture for the cuttings. In semi-arid to arid regions, the upper portion of the streambank may not have enough permanent moisture to establish the cuttings. Thus, other techniques may be required. Give careful attention to the upstream and downstream ends of the treatment area to prevent flows from getting behind the layers. Tying into existing features onsite, such as trees and rocks, or the additional placement of brush and rocks are possible solutions.

Brush Mattress, Practice #302, Mild Engineering

A brush mattress makes use of a mat of live willow cuttings along the slope of an eroding streambank, placed in a trench at the toe of the slope and anchored with a fascine. A grid of rope and wooden stakes is used to secure the mat to the slope in an upwards direction with the length of the willow cuttings facing away from the waterbody. The willow cuttings will sprout and take root, thus stabilizing the streambank with a dense matrix of roots. Brush mattress treatment provides immediate protection for eroding banks equivalent to 4–6 inch rock. Over time, the live poles root into the bank, creating strong, living bank protection.

This practice results in a reduction of streambank erosion, reduction in surface water contaminants (i.e., sediments, nutrients, and organics), and improved habitat suitability by addressing low dissolved oxygen, habitat alteration, and water temperature. The effectiveness of this application is moderate reduction of load potential, but has a low maintenance requirement. Improvements to water quality can be seen in as little as a few months.

No permits are required if plants are installed by hand. However, if toe rock is used, permits under Section 401 and 404 of the Clean Water Act may be required. In many cases, toe rock will be necessary to provide adequate protection. In addition to toe protection, erosion control fabric can be used to protect the soil between the layers.

Prepare the slope of the streambank by clearing away large debris. However, do not remove woody debris from the stream channel because this provides important fish habitat. The brush mattress technique is probably most effective on slopes no steeper than 2:1. Excavate a horizontal trench, 8 to 12 inches deep, at the toe of the streambank along the length of area to be treated. Place the willow cuttings in the trench. Make sure the ends reach the bottom of the trench. Spread the cuttings along the face of the slope until a thickness of 4 to 6 inches is achieved. Pound a grid of 36-inch long wooden stakes into the mattress every 3 to 4 feet on center. Use longer stakes in less cohesive soil. Secure the brush mattress by using 3/8 inch rope tied in horizontal runs and then diagonally between each row of stakes. After wiring the mattress, drive the stakes in further to compress the mattress tightly against the streambank. Construct a fascine the length of the area to be treated. Backfill around the fascine and mattress by using material excavated from the trench, making sure to work soil into the branches. Use buckets of water to wash the soil down into the stems. Key the upstream end of the mattress and fascine into the streambank to prevent high flows from getting behind the mattress. It is a good idea to protect this area with some revetment, large rocks, or tree trunks.

Brush Revetment, Practice #303, Mild Engineering

Brush or trees are secured around the streambanks to slow excessive erosion by diverting the current away from the bank's edge. The revetment material does not need to sprout. Revetment involves a conical shaped gathering of plant material applied lengthwise to the toe of a streambank and secured with wooden stakes and horizontal runs of rope. Always plant willows or other quickly sprouting species behind the revetment to provide permanent cover. The purpose of this practice is to reduce sediment input to streams caused by erosion of raw or sloughing streambanks. The revetment also traps sediment from the stream and sloughing streambank and provides overhead cover for fish habitat. This practice has a moderate reduction of potential loads of salinity, sediments, nutrients and organics and has low maintenance requirements. Results can be seen between a few months to 2 years of implementation. This practice can be applied streamside or on developed lands.

Installation of brush or tree revetment can usually be accomplished throughout the year. For safety reasons, avoid high water periods. Typically, the trunks of the revetment should be placed between the annual low and high water levels. In areas of extreme fluctuation in water levels, it may be necessary to place a second row of revetment at the high water line to prevent scouring behind the revetment during flood events. It is critical that the revetment extend upstream and downstream at least 1 to 3 tree lengths past the eroded area being treated to prevent flows from getting behind the revetment. It is vital to the success of this practice to secure the upstream and downstream ends into the bank and reinforce with additional brush or rock. These end points are the sections most likely to fail and require substantial protection. Never disturb the site unnecessarily. Remember that the goal is to stabilize a site. The less it is disturbed, the easier it will be to restore.

Vertical Bundle, Practice #304, Mild Engineering

This technique uses bundles of willow cuttings (*Salix spp*.) placed in vertical trenches along an eroding streambank. The willow cuttings will sprout and take root, thus stabilizing the streambank with a dense matrix of roots. This practice applies to streambanks of natural or constructed channels and shorelines of lakes, reservoirs, or estuaries where they are susceptible to erosion. Erosion is controlled by the physical structure of the woody stems increasing roughness and providing bank protection. This practice has a high potential for reducing sediments, salinity, water temperature, habitat alteration, nutrients and organics. Additionally, this technique can be applied streamside with minimum maintenance required.

As with similarly designed brush applications, Coyote willow (*Salix exigua*) is an especially good species for this method because of its dense root system. This technique can also be used with redoiser dogwood

(*Cornus spp*.). However, to encourage rooting with dogwoods, the stems need to be manually nicked or cut and treated with rooting hormone.

Some protection should always be placed in front of the bundles. In particular, the toe of the slope is very susceptible to erosive flows. Analysis and calculations of forces will provide guidance on suitable toe protection. Careful attention must be given to both endpoints of the treatment to prevent flows from getting behind the bundles. Tying into existing features onsite, such as trees or rocks, or using additional brush revetment are possible solutions.

Section 404 and 401 Permits of the Clean Water Act are required if mechanical means of installation are used, and if this technique is applied in conjunction with an extensive stream project. In areas where riprap is being placed, vertical willow bundles can be installed prior to placement of the riprap. Instead of installing a geotextile fabric on the streambank, pea gravel should be used. This will allow willow growth to protrude through the riprap. Avoid disturbing the site as this reduces the success of the application and might prolong the restoration rate for the area.

Willow Fascines, Practice #305, Mild Engineering

Willow wattles (*Salix spp*.) or live fascines are cigar- or sausage-like bundles of live cuttings tied together and inserted into a shallow trench dug into the streambank at the streamside. The purpose of this practice is to reduce erosion on streambanks by reducing the force of water against a bank. The willow bundles will sprout and take root, thus stabilizing the streambank with a dense matrix of roots. This is a good technique to break up slope length and minimize erosion, thereby addressing pollutants such as sediments, salinity, habitat alteration, water temperature, nutrients, and organics. This technique has a high load reduction potential and a low maintenance requirement.

As with similarly designed brush applications, Coyote willow (*Salix exigua*) is an especially good species for this method because of its dense root system. This technique can also be used with redoiser dogwood (*Cornus spp*.). However, to encourage rooting with dogwoods, the stems need to be manually nicked or cut and treated with rooting hormone. Rooting hormones and fertilizers do not significantly improve success for the cost of materials and should be taken into consideration when developing a site specific plan to implement this activity.

If this method is used in a highly erodible area, some protection should be placed in front of the wattles to prevent scour. Analysis and calculations of forces will provide guidance for suitable tow protection. In some cases, brush revetment or fiberschines may be adequate, while other situations may require rock. If other protection is used, the wattle should be 12 to 24 inches in diameter. Section 404 and 401 Permits of the Clean Water Act are required if mechanical means of installation are used and if this technique is applied in conjunction with an extensive stream project.

Another variation of this technique is to cover the wattles with erosion control fabric to prevent the soil from being undercut from the wattles. Poles can be planted into the permanent water table between the wattles. Rock toe can also be used to prevent scour. Avoid disturbing the site as this reduces the success of the application and could prolong the rate of restoration.

Brush Trench, Practice #330, Mild Engineering

This technique uses bundles of willow cuttings (*Salix spp*.) in a buried trench along the top of an eroding streambank. The willow cuttings will sprout and take root, thus stabilizing the streambank with a dense matrix of roots. The willow “fence” filters storm runoff or irrigation return flows before it enters the stream and is a good method of alleviating piping problems. This technique has a high potential to reduce pollutant loads. In addition, results can be seen in a few months to two years after implementation, and this technique has a low maintenance requirement. This technique can be applied streamside and on agricultural and developed lands to address sediments, salinity, water temperatures, nutrients and organics. No permits are required if the technique is installed by hand or away from a stream or wetland. If wetlands are impacted or if the installation technique is other than manual, Section 401 and 404 of the Clean Water Act may be required.

Coyote willow (*Salix exigua*) is an especially good species for this method because of its dense root system. This technique can also be used with redoiser dogwood (*Cornus spp*.). However, to encourage rooting with dogwoods, the stems need to be manually nicked or cut and treated with rooting hormone. A critical inventory step is to determine the availability of moisture to the cuttings. Either the cuttings will have to reach the capillary fringe of the permanent water table, or there will need to be sufficient overland runoff or bank seepage to sustain the willows. Another critical step with this technique is to determine if toe protection is necessary. In some cases, brush revetment or fiberschines may be adequate, while in other cases, conditions may require rock. In addition to the toe protection, a treatment for the mid-bank may also be needed.

As with similar applications, give careful attention to both endpoints of the treatment to prevent flows from getting behind the trench. Tying into existing features onsite, such as trees or rocks, or using additional brush or rock are possible solutions. Never disturb the site unnecessarily. Remember that the less it is disturbed, the easier it will be to restore.

Erosion Control Fabric, Practice #331, Mild Engineering

Erosion control fabrics are commercially available products that can be used to prevent erosion on slopes. This is an interim measure until vegetation establishes and has a chance to stabilize the slope. Woody cuttings and herbaceous plants can be planted into the fabric and seed can be placed underneath the fabric. This can be applied streamside and to agricultural and developed lands to prevent erosion, thus addressing sediments, salinity, pesticides, water temperature, nutrients, and organics loading into watercourses.

An important step in this technique is to ensure the upstream and downstream ends of the erosion control blanket are well keyed into the bank to prevent high flows from pulling the blanket out. Cobble should be placed in the key trenches to prevent the fabric from being pulled out. Another important step is where the fabric overlaps—it should be shingled away from the direction of the current to prevent flows from pulling at the fabric. Never disturb the site unnecessarily. If the area is grazed, restrict livestock from treated areas to allow the eroded section of the streambank to establish. Exclosure fences are the most efficient means to accomplish this goal. Managers should resist the temptation to put the exclosure fences at the high-water line. The exclosure areas should include enough of the riparian zone to allow the stream to shift naturally over time. If the area is farmed, a riparian buffer strip should be established and maintained. A buffer strip on both sides of the stream should be set aside to allow for natural riparian vegetation and stream function. A wider buffer strip is strongly encouraged and will yield greater benefits.

Fiberschines/Biologs, Practice #332, Mild Engineering

This technique uses a coconut-fiber roll product to protect the streambank by stabilizing the toe of the slope to trap sediment from the sloughing streambank. This technique provides protection from erosive currents on the toe of streambanks. Cuttings and herbaceous riparian plants are planted into the fiberschines and behind it. By the time the fiberschine decomposes, riparian vegetation will have stabilized the streambank by providing a strong root matrix. This technique is applied streamside to address sediments, salinity, nutrients, and organics as pollutant sources. It has a low load reduction potential and a low maintenance requirement.

Installation of the fiberschine can usually be accomplished throughout the year. High-water periods should be avoided for safety reasons. The fiberschine should extend upstream and downstream past the eroded area being treated to prevent flows from getting behind the fiberschine. Analysis and calculations may reveal that additional toe protection is necessary. In many cases, rock may be appropriate if placed properly. Improperly placed rock can result in erosion problems on the opposite streambank as well as downstream. Installation methods that are other than manual may require permits from the appropriate administrative agency.

Be sure to key the upstream and downstream ends of the fiberschine into the streambank and secure it with some hard materials, such as tree trunks or large rocks. If this method is used in a highly erodible area and bank shaping is not possible, a tiered fiberschine technique may be necessary. Three fiberschines of different diameters are often used, but various numbers and combinations of sizes can be used. Disturbing the site after installation of this technique may result in reduced success and may extend the restoration time.

Silt Fence, Practice #333, Mild Engineering

Silt fence is a porous fabric barrier installed to temporarily contain surface sediments on disturbed lands. The silt fences are available commercially and are used to contain loose sediments generated on construction sites and other disturbed areas, such as agricultural and developed areas. Water is allowed to flow through the fabric while sediments are trapped. This technique has a moderate load reduction potential with effects observed immediately after implementation. Maintenance requirements of silt fences are high compared to other erosion control measures.

Silt fences are installed perpendicular to overland water flow. In large areas, fences are installed in series to slow the flow of water across disturbed lands. These fences should be considered temporary, installed to buy time for seeding or other revegetation practices to establish. While the practice does not generally require regulatory permits, it is often a requirement in stream alteration permits to minimize pollutants during construction projects.

Straw Roll/Bale Barrier, Practice #334, Mild Engineering

A straw roll/bale barrier is a semi-permeable barrier to contain sediments generated by flows across bare or disturbed ground on agricultural or development lands. Ground disturbances created during construction can result in quantities of sediment and other pollutants as storm flows erode surface soils. The barriers temporarily trap sediments, salinity, nutrients, and organics while allowing waters to flow through. This practice has a moderate reduction potential with immediate results observed following implementation. Straw bales are temporarily placed perpendicular to surface sheet flow. In small channels, velocities are high enough to require anchoring of the bales with steel or wooden stakes. These barriers should be considered temporary and require substantial maintenance.

Watering Facility, Practice #370, Mild Engineering

A watering facility is a device (i.e., tank, trough, or other watertight container) used to provide animal access to water. The purpose of these facilities are to provide watering for livestock or wildlife at selected locations to protect and enhance vegetative cover, provide erosion control through improved grassland management, protect streams, ponds and water supplies from contamination by providing alternate source of water. This practice has a moderate potential to reduce pollutant loads of sediments, salinity, pathogens, low dissolved oxygen, water temperature, nutrients, and organics. Improvements are observed immediately after implementation, and maintenance requirements are low. Topography should be evaluated to minimize trail erosion and flooding erosion from tank overflow. Watering facilities should be accessible to small and large animals. Escape ramps for birds and small animals should be installed. Adequate protection for livestock during winter should be considered. In addition, accommodations should be made to allow for ice expansion to preserve the integrity of the structure.

Level 400 Practices

Grade Stabilization Structure, Practice #420, Moderate Engineering

A grade stabilization structure is used to control the grade and head cutting in natural or artificial channels. These structures can consist of rock, rock and brush, or rock and biologs. The purpose of this technique is to stabilize the grade and control the erosion in natural and artificial channels to prevent the formation or advance of gullies. There can be significant reduction in classic gully erosion and a moderate reduction in streambank erosion with significant reduction in surface water suspended sediments. Results are observed immediately after implementation with moderate maintenance required.

Grade stabilization structures are located streamside so that the elevation of the inlet of the spillway is set at an elevation that will control upstream headcutting. A wide range of alternative types of structures are available for this practice, and an intensive site investigation is required to plan and design an appropriate grade stabilization structure for a specific site. Section 401 and 404 permits may be required.

Irrigation Pipeline, Practice #450, Moderate Engineering

This application involves installing a pipeline and appurtenances as an integral part of an irrigation system or stormwater control network. The purpose of the practice is to reduce erosion, conserve water, and protect water quality. Underground pipelines serve as an integral part of the irrigation water distribution system and significantly improve the overall efficiency of the system. Moderate reductions in sheet, gully, and irrigation-induced erosion can occur. This practice can be applied to agricultural and developed lands to address sediments, salinity, nutrients, and organic pollutants. Maintenance requirements are low, and results can be observed immediately after implementation. Pipelines must be properly sized and installed. The pipe diameter is a function of the length of pipeline, the expected flow, and the slope. For pipelines of any length, engineering is often required.

Irrigation System, Drip, Practice #451, Moderate Engineering

This application involves a planned system in which all necessary components have been installed for efficient application of irrigation water directly to the root zone of the plants by means of emitters, orifices, or porous tubing. The purpose of this technique is to efficiently and uniformly apply irrigation water and to maintain soil moisture for optimum plant growth. Moderate reductions in sheet and gully erosion are observed along with moderate reduction in surface water suspended sediments. Improvements to water quality can be seen immediately after implementation. Moderate potential to reduce pollutant loading exist. A moderate level of maintenance is required to sustain system functionality. The primary location for application of this type of technique is agricultural lands.

Water quality is usually the most important consideration when determining whether a drip system is feasible. Well and surface water often contain high concentrations of undesirable minerals. Surface water can contain organic debris, algae, moss, bacteria, soil particles, etc. that can affect the mechanical operation of the system. Well water can also contain sand.

Drip irrigation can influence runoff and deep percolation by raising the soil moisture level and decreasing the available soil water storage capacity, increasing the probability of runoff or percolation below the root zone from storm events. The movement of sediment, soluble chemicals, and sediment-attached substances carried by runoff could affect surface water quality. The movement of dissolved substances below the root zone might affect groundwater quality.

On systems where chemicals are injected, care shall be taken so the injected nutrients do not react with other chemicals in the irrigation water to cause precipitation and plugging. Drip irrigation will effect a change in plant growth and transpiration because of the changes in the volume of soil water. There may be a potential for development of saline seeps or other salinity problems resulting from increased infiltration near restrictive layers. Field shape and slope frequently dictate the most economical lateral direction. Whenever possible, laterals should be laid downslope for slopes of less than 5 percent if lateral size reduction can be attained. For steeper terrain, lateral lines should be laid along the field contour and pressure compensating emitters should be specified or pressure control devices used along downslope laterals.

Irrigation System, Sprinkler, Practice #452, Moderate Engineering

A sprinkler irrigation system is a planned system in which all necessary components have been installed for efficient application of irrigation water by means of nozzles operated under pressure. The purpose of a sprinkler irrigation system is to efficiently and uniformly apply irrigation water to maintain adequate soil moisture for optimum plant growth without causing excessive water loss, erosion, or reduced water quality. These systems can reduce sheet, gully, and irrigation-induced erosion, reduce suspended sediments in surface water, and improve habitat suitability. These systems result in moderate reduction of potential pollutants such as sediments, salinity, pesticides, nutrients and organics. Additionally, results can be seen immediately following installation with moderate system maintenance required.

Traditionally, these systems are installed on agricultural lands. Sprinkler irrigation designs are determined on the basis of an evaluation of the site considering soil, topography, water supply, energy supply, crops to be grown, labor requirements, and expected operating conditions. Sprinkler irrigation systems are a better choice for sandy soils. Conversely, if the soils have low permeability (i.e., have a high clay content), the site may not be well adapted to sprinkler irrigation due to excessive runoff and erosion.

The net depth application is calculated using the available moisture capacity of the soil in the root zone of the irrigated crop or a lesser amount consistent with the land user's operation plan. The gross depth shall be determined by using field application efficiencies consistent with the conservation of water resources.

The design rate of application shall be within a range established by the minimum practical application rate under local climatic conditions and the maximum rate consistent with the intake rate of the soil and the conservation practices applied on the land. If two or more sets of conditions are used in the design area, the lowest maximum application rate for areas of significant size shall apply.

Distribution patterns and spacing shall be evaluated to accommodate individual site conditions. A combination of sprinkler spacing, nozzle sizes, and operating pressure that provides the design application rate and distribution shall be selected. The velocity of prevailing winds and other conditions must be considered.

Irrigation System, Surface, Practice #453, Moderate Engineering

A surface irrigation system is one in which all necessary water-control structures have been installed for the efficient distribution of water on agricultural lands by surface or subsurface means. Surface methods include such applications as furrows, borders, contour levees, or contour ditches. The purpose of this practice is to efficiently convey and distribute irrigation water to the point of application without causing erosion, water loss, or reduction in water quality. The application of surface irrigation systems result in moderate reduction in sheet, gully, or irrigation induced erosion with moderate reductions in suspended sediments in surface water. Surface water pollutants addressed include sediments, salinity, pesticides, nutrients, and organics. Moderate maintenance is required, and improvements can be seen immediately after installation.

When planning this practice, the following items should be considered, where applicable:

- Effects of nutrients and pesticides and other dissolved substances on surface and groundwater quality
- Effects of water level control on the salinity of soils, soil water or downstream water quality
- Effects of water levels on such soil nutrient processes as plant nitrogen use or denitrification
- Impact of salt leaching on system management and capacity requirements

Implementation considerations include the water budget, especially volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge. Plant growth and transpiration are strong factors to consider because of the changes in the volume of soil water. Implementation of surface irrigation systems will impact the field water table in providing suitable rooting depth for anticipated land uses. Erosion and the movement of soluble and sediment-attached substances should be carefully evaluated to mitigate impacts to local and downstream users. The impacts to aquatic and wildlife communities, wetlands or water-related wildlife habitats, existing and future downstream users (specifically looking at social, physical and chemical effects), and visual and cultural resources should be evaluated.

Road Stabilization, Practice #470, Moderate Engineering

The stabilization of roads and other embankments by use of rock, vegetation or geotextiles reduces sediment inputs from erosion and protects the related infrastructure. Traditional stabilization relied on expensive rock treatments. Other options available include, but are not limited to, the use of erosion-control fabric, toe rock, and plant materials to stabilize banks. This practice addresses sediments, salinity, pesticides, nutrients, and organics and can be applied to agricultural and developed lands.

Planning considerations include the height and slope of the bank, the climate, and value of the road or infrastructure. In general, hardening the bank with rock riprap is the most costly approach. Often the installation of native plant materials can spread and reduce runoff erosion. Erosion-control cloth can be used to temporarily stabilize the bank until the vegetation is established. Permits under Section 404 and 401 of the Clean Water Act are required if the bank is adjacent to a stream or wetland.

Level 500 Practices

Constructed Wetland, Practice #500, Intense Engineering

A constructed wetland is a complex built to filter and clean domestic or livestock operation wastewater, agricultural irrigation returns, or other waters. The biological processes in wetland systems can significantly improve water quality. These facilities are designed to provide final cleaning to wastewater once solids and pathogens have been removed. This application addresses sediments, salinity, water temperature, nutrients, and organics. It has a moderate potential to reduce pollutant loads to waterbodies with results expected in a few months to two years after implementation. This technique has a low maintenance requirement and can be applied streamside to agricultural and developed lands. Permitting requirements vary depending on the location. A permit from under Section 401 and 404 of the Clean Water Act may be required.

Constructed wetlands are complex physical and biological systems. Individual cells are designed in series to sequentially clean waters. Vegetation types and flow velocities should be carefully designed to meet project objectives. Water quality monitoring procedures will need to be implemented in concert with this technique to monitor improvements.